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RECON STUDY HURRICANE AGNES.(U)

OCT 72 DACW61-73-C-0146

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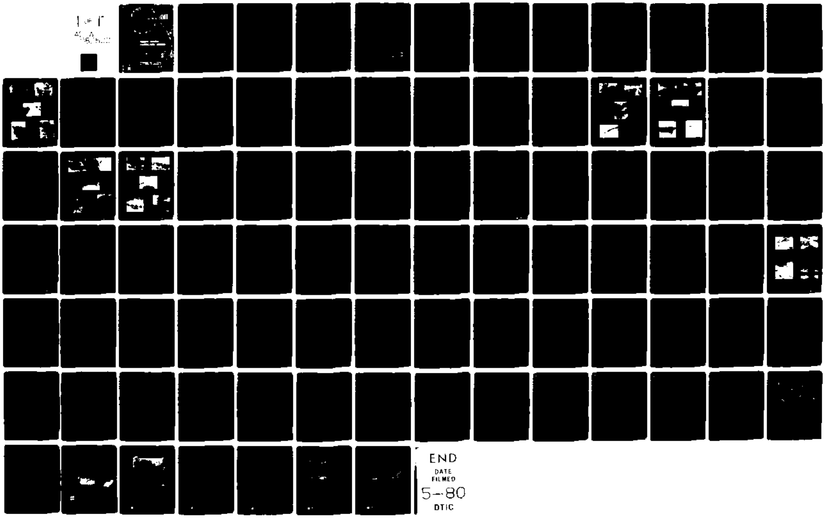

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Floods	Water Quality	
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The major objective of this study was to make a preliminary overview analysis of the ecological impact of Hurricane Agnes on inland areas of short (up to 1 year), intermediate (1 to 2 years), and long term (beyond 2 years) effects. The following factors were surveyed by this study : geological characteristics, soil erosion & sedimentation, tree damage, wildlife and related habitat, fishlife, water quality, recreation areas, historical monuments and economic impact of Hurricane Agnes upon the region.

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The geographical area covered by this study is bounded on the north by the City of Syracuse, New York, on the east by Philadelphia, Pa, on the West, by the Ohio-Pennsylvania State Line and on the south by the Virginia-North Carolina border.

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LEVEL II

O'BRIEN & GERE
ENGINEERS, INC.

October 20, 1972

Colonel Carroll D. Strider, District Engineer
U.S. Army Engineer District Philadelphia
Corps of Engineers
NAPENE
Philadelphia, Pa.

Attn: John Burnes, PhD

Re: 333.005

Dear Colonel Strider,

Please find enclosed our report on a preliminary "overview" of the ecological impact of the flooding caused by Hurricane "Agnes". The major impact was in the areas of stream modification, displacement of adult fish, small fish and small game kills and damage to and loss of recreational facilities.

This report can serve as a guide to immediate corrective programs and more detailed investigations for intermediate and long term effects, many of which are underway.

We trust that this report meets with your approval and hope that it may serve in the best interest of the future Corps programs.

Very truly yours,

O'BRIEN & GERE ENGINEERS, INC.

Frank J. Drehwing

Frank J. Drehwing, P.E.
Research Division

FJD:kas

CONTRACT NO. DACW61-73-C-0146

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DOVER, DELAWARE CHARLOTTE, NORTH CAROLINA

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GENERAL

The net result of Hurricane Agnes was one of the worst flood devastations in the recorded history of this country. The flood has been estimated to have caused over four billion dollars in property damage. Aside from the measurable damage to property, impact on the ecology of the area was far less definable but nonetheless significant, and may become evident in retrospect only after the years nature and man may require to recover. Certain elements of ecology modified or destroyed by the flooding are of an irreplaceable nature.

It is recommended that "An Overview of Ecological Impact" reported herein should serve as a guide to the more detailed investigations the needs for which have become evident through this study.

GEOLOGICAL CHARACTERISTICS

The geology of a given area is a major determinant of drainage patterns as well as the quantity of soil erosion and sedimentation that occur during a heavy rainfall and subsequent runoff. Although general geological characteristics were known for the area under study, additional information will enable a more thorough assessment of causes, and will contribute to the corrective steps that can be taken for future planning.

It is therefore recommended that additional characteristics of drainage areas be considered such as the following:

a. Basin morphometry including stream order and stream length per order as well as drainage density

b. Flow budgets including subsurface contributions

c. Sediment and erosion rate studies including distribution profiles

d. Aggradation and degradation of stream bank materials

It is further recommended that the above information, much of which is presently available in scattered form, be developed into a typical working model that can be applied as a management guide to all streams.

SOIL EROSION AND SEDIMENTATION

The severe soil erosion and siltation caused by Hurricane Agnes could have been reduced if more adequate conservation practices were followed both on agricultural and non-agricultural land tributary to water courses. Such practices on agricultural land would include strip farming and crop rotation, contour plowing, and planting of cover crops during the winter to prevent soil erosion as does occur during every spring runoff. Diversion terraces such as broad shallow channels that intercept and divert excess runoff water to a safe outlet could be constructed to limit erosion from farm lands Many of these practices have been instituted by agricultural agencies but may require more frequent surveillance

In and along water channels, such stream improvements devices as rock deflectors, dams, gabions, cribbing, and stream bank plantings would greatly enhance the ability of a stream to resist erosion and deposition The construction of these devices normally makes use of materials on site such as rocks, fallen trees and logs

Other measures that could be taken for stream bank erosion control include:

a The avoidance of plowing too close to the stream banks

b. Preventing cattle from having access to major streams since these accesses in themselves provide pathways of erosion

Many of the stream reclamation projects were severely criticized by conservation agencies in regards to the following

In some instances, dredging of the streams was unnecessary since the hydraulic capacity was not seriously affected and soil deposits were fairly well stabilized shortly after the flooding By moving these deposits from one bank to the other, as at a bend in a stream channel, little was accomplished aside from adding to the turbidity and suspended solids concentration of the stream

These only slightly compacted banks would be extremely vulnerable to erosion next spring

It is recommended that rock deflectors or rip-rap be installed on the outside corners of bends to protect these banks from erosion Since the inside bank is well stabilized, additional reinforcement would not be required

A second observation reported was the failure to provide adequate low-flow channels The result was a puddling effect where water flowed from one puddle in a stream bed to another in a little rivulet, or in some cases the retention of water for a long enough period to prevent any net flow Related thereto was the manner in which much of the material removed from stream channels was deposited on the flood plain The distribution and nature of much of this material will not support adequate plant life to prevent erosion following normal spring runoff

The practices outlined above in large part can be attributed to the "emergency" nature of the reclamation contracts In almost all cases there was no information on the physical dimensions of low-flow channels It is therefore recommended for future application that major stream channels be described in sufficient detail so as to allow the reconstruction of these channels In addition all existing streams should be evaluated as soon as possible, with respect to additional low-flow channel reconstruction and spoil distribution

TREE DAMAGE

The tree damages suffered in the study area are minor when compared with the magnitude of other damages such as soil erosion, sedimentation and loss of fish habitat In most cases trees damaged and lost were along stream banks and were caused by washing of trees by high velocity, exposure of root systems and in some cases high dissolved solids concentration, thus impairing uptake mechanisms In some cases sustained periods of inundation resulted in subsequent fungus infections which effectively girdled many trees Since root systems play such a vital role in the stabilization of stream banks, trees should be replanted as soon as possible.

It is recommended that prior to the planting of new trees, evaluations be made to determine what species of tree best will withstand the conditions of that area Such trees as the willow, alder, and dogwood can provide the best vegetation cover in the shortest length of time.

WILDLIFE AND RELATED HABITAT

Hurricane Agnes and the cool weather which preceded it resulted in widespread mortality of wildlife This was particularly well documented among bird populations However, with the exception of a few species noted herein, the population will more than likely recover within a few years

If the continuing surveillance by naturalists throughout the northeast reveals a severe and persistent decline of any wildlife species, it is recommended that human activity such as hunting and spraying be curtailed In some cases where intensive or special use areas have sustained habitat alterations, it is recommended that these areas be restored as soon as possible

FISHLIFE AND RELATED HABITAT

There are many inter-related factors which may act as a detriment to fish subjected to flood conditions It is apparent from the results of this study that more data concerning the effects of flood conditions on fish must be collected in order to make reliable estimates of damage In addition, the full effect of the flooding may not be evaluated for several years and may not easily be documented because of lack of information about conditions prior to flooding In general, major damage was done to the fingerlings, since it is doubtful that they survived either the conditions during flooding or the strange environment, such as the bay areas, they may have had to contend with shortly thereafter. Little or no damage was done to the larger adult fish however, which were displaced from their former habitat This displacement may result in some significant reductions to businesses supporting sport fishing

It is recommended that more detailed biological surveys be conducted in pre-selected streams in order to enable an adequate assessment of the impact of flooding conditions.

WATER QUALITY

Water quality in the entire area under study was influenced markedly by the 1972 flood waters. The immediate concern was that of health and safety to the eneral public. As a necessary result, the water quality as related to its effects on ecology was of secondary concern, and data were in most cases non-existent. In addition, baseline data were for the most part deemed inadequate to allow comparisons with "flood" data, if the latter were available. An apparent problem revealed by this study was the lack of coordination between various state and federal surveillance networks.

It is recommended that a centralized comprehensive surveillance network be established in each state for major streams and tributaries. It is further recommended that guidelines for the operation of such networks be established by a federal agency in order to promote some degree of uniformity between states as related to the type of data gathered, manner and location in which they are to be stored and uses to which the data can be put. The federal "STORET" system is a good example of a coordinated effort intended to make available various data to state, federal and private organizations upon request.

Stream water quality data should include in addition to basic parameters, bottom samples in order to assess sediment water interfacial relationships. These samples should be collected at pre-selected locations chosen to be significant with respect to other water quality parameters.

RECREATION

Since many outdoor recreational activities are water oriented, or water enhanced, most recreational sites are located near bodies of water. Based on sporadic inputs, it has been established that attendance at state parks may have been reduced by as much as 20% during the 1972 season. With the increasing demand for recreational sites throughout the country and the persistance of vacationers, 1973 attendance is not expected to be affected except where damaged facilities will not have been repaired.

The only preventive measures that can be taken in regard to recreational facilities is either to re-locate them in areas not highly susceptible to flood damages or where siltation was the major problem, to apply soil conservation measures as outlined under the section titled "Soil Erosion and Sedimentation."

Revenue losses suffered by the sport fishing industry could range from 15 to 40% resulting in a revenue loss of twenty to eighty million dollars respectively. These losses may be incurred until fishermen have located new spots.

HISTORICAL MONUMENTS

Most damage to historical monuments was of an unpreventable nature. Historical buildings and other structures of an historical nature such as bridges, sawmills and such areas as Harper's Ferry and Forty-Fort Cemetery, can only be protected by as much as the particular situation will allow, i.e., sandbagging around the areas when high flood waters are expected.

It is recommended that historical manuscripts, books, photographs, etc be located on the upper floors of museums to prevent water damage as was the case in the Agnes flooding

SUMMARY

It is recommended that this study be used as a guide to define the need for more detailed investigations and monitoring of the environment. For those impact statements that are designated as short-term, immediate corrective steps are recommended

CATHERINE CK., N.Y.
STREAM GRAVEL DEPOSITS

LITTLE MUNCY CK., PA.
NO APPARENT FLOW AFTER
CLEAN UP EFFORT

LITTLE SHAMOKIN CK., PA.
POOR BANK MATERIAL FOR RESEEDING

HAMMONDSPORT, N.Y.
NO SUMMER CHANNELLING DURING
CLEAN UP EFFORT

BRADNER CK., N.Y.
PUDDLING EFFECT AFTER
CLEAN UP EFFORT

INTRODUCTION

BACKGROUND

On June 17, 1972 what appeared to be a minor tropical disturbance off Cozunel Island between the Yucatan Peninsula and Cuba developed into a hurricane Although the hurricane veered out to sea, rather than losing strength, it picked up new strength from the ocean and turned inland toward the northeastern states On June 22nd, the huricane's path suddenly changed from a northerly direction to a southwesterly direction caused by 1) the stalling of a high pressure cold front in the west and 2) a strong ridge in the upper air over the Atlantic Ocean blocking the path of the storm to the sea On June 23rd, the Hurricane again took a northerly course and at midday was west of Elmira moving toward the Syracuse area. It finally died out on June 24th as it appeared to be making its second loop toward the Elmira area. As a result, intense rainfalls occurred in an area generally bounded by Plattsburgh, New York in the north to Richmond, Virginia in the south An outline of the path of the hurricane on a contour map illustrating the degrees of rainfall intensity is shown in Figure 1.

The rainfall intensities illustrated in Figure 1 resulted in ground saturation over a relatively short period of time causing intense runoff and severe stream flows The net result was one of the worst flood devastations in the recorded history of this country The flood has been estimated to represent a return period in excess of 250 years The storm left behind, in its ten-day lifetime, 181 dead, 3 missing, 100,000 without shelter and in the order of 4 billion dollars in property damage, an estimated which is continuously being revised upward The states that experienced the largest amount of damage were Pennsylvania, New York, Virginia, Maryland and the Washington, D C area Whereas previous hurricanes have been known to cause flooding in minor tributaries, the combination of previous rain plus new rain from Agnes resulted in the flooding of such major rivers as the Rappahannock, James, Potomac and the Susquehanna, cresting their fall lines on the 22nd, 23rd, 24th and 25th of June respectively The relative impact of the flooding on the various states is shown in Table 1

As early as Wednesday, June 21st, authorities were notified of the impending flood resulting in the mobilization of field personnel from various state and federal agencies The immediate objective was to save lives wherever possible At the same time, emergency headquarters of the Office of Emergency Planning were set up at various locations throughout the affected area to direct recovery operations Officials from State and Federal Agencies and representatives from the Corps of Engineers were mobilized to evaluate the extent of damages and to implement emergency relief to flood-ravaged communities and victims The vast majority of officials was involved in compiling damage survey reports in order that streams could be cleared of debris and critical services restored The Corps of Engineers was authorized by a mission assigned from OEP to proceed with stream reclamation, provide emergency temporary repairs for the restoration of water and sewage facilities and the removal of bridges destroyed by the flood Other officials were engaged in evaluating claims for reimbursing emergency relief and repairs submitted by communities from reports generated by survey teams comprised of local officials, state officials and a representative of the Corps of Engineers.

Simultaneously, efforts were made to collect information that would assist in evaluating the impact of the flooding on the ecology of the area Provisions are being made through the Baltimore and Philadelphia Corps offices to evaluate such impact on the areas affected by inland streams as well as the Delaware and Chesapeake Bays This study reports on the impact of the flooding caused by fresh water streams not including those reaches defined as estuaries tributary to the aforementioned Bays

STUDY OBJECTIVES

The major objective of this study is to make a preliminary "overview" analysis of the ecological impact of Hurricane Agnes on inland areas in terms of short (up to 1 year), intermediate (1 to 2 years), and long term (beyond 2 years) effects It is intended that this study will serve as a guide to more detailed investigations and monitoring of the environment Factors surveyed by this study include the following:

Geoglogical Characteristics
Soil Erosion & Sedimentation
Tree Damage
Wildlife and Related Habitat
Fishlife and Related Habitat
Water Quality
Recreation Areas
Historical Monuments
Economic Impact

Whereas redefinition of flood plains was to be considered in the study, upon initiation of this project, it was found that this work was being done by district offices of U S G S and the Corps of Engineers Hence this was deleted from the scope of work.

The area most severely affected and covered by this study is shown in Figure 2 and is further described as being bounded on the north by the City of Syracuse, New York, on the east by the City of Philadelphia, on the west by the Ohio-Pennsylvania state line, and on the south by the Virginia-North Carolina border The river basins within this area most affected and covered by field inspections under this study were the Susquehanna, Allegheny, Genesee, Cohocton, Canisteo, Passaic, Schuylkill, Shenandoah, Potomac, James, Ohio, Rappahannock and Patapsco This study is a preliminary overview of the various ecological factors as opposed to more comprehensive and detailed studies which in many cases have been initiated and will continue for some time to come. Such a preliminary study is beneficial in that it can serve as a coordinating device for the various governmental agencies undertaking the more detailed studies and serves to expose areas of need for such studies

LIMITATIONS

Owing to the nature of this study, the degree of completeness of records covering the various factors outlined above will vary with respect to location and type of agency Since the most urgent need, following the subsidence of flood water, was to assist in the supplying of food to the needy and the replacement of living quarters ravaged by the flood, many observations owing to fish and wildlife were not recorded by the respective agencies.

The flooding generally attributable to Hurricane Agnes has been associated with the cause of much of the ecological damage; however, prior to the arrival of "Agnes" there was considerable rain throughout the spring months, particularly from mid April through the month of May. Thus, much of the ground was already saturated with attendant high ground water tables. In addition, the extended rain undoubtedly had its own impact on fish and wildlife as further described in this report.

APPROACH

Since the main task was to secure existing information, contact was made with all state and federal agencies involved in ecological investigations of their own. In addition, field inspections were conducted to observe the effects first hand. Since much of the information being amassed by various state and federal agencies was either in the process of being collected from various regional offices or under evaluation during the implementation of this study, the major share of data were obtained through the local contacts and field inspections. Reference data on the economic impact of damages were obtained through the North Atlantic Regional Water Resources Study, May 1972.

TABLE 1

DAMAGE REPORT
TROPICAL STORM AGNES
June 21, 22, 23, 1972

	Pennsylvania	New York	Maryland	Virginia	Total
Rainfall	17.6 in.-36 hrs.	14 in.-24 hrs.	11.55 in.-24 hrs.	15 in -48 hrs.	
Counties severely affected	23	20	10	55	108
Total Estimated Damage	$3,000 million	600 million	94 million	163 million	3,857 million
Loss of life	116	24	19	22	181
Watershed Projects in severely affected area	11	5	3	27	46
Number of Floodwater Retarding Structures Installed	28	30	8	95	161
Miles Channel Improvement Installed	0	0	0	150	150
Number of Emergency Spillways Used	2	0	0	29	31
Estimated damage to Floodwater Retarding Structures	$ 19,000	0	0	$ 66,200	$ 85,200
Estimated damages prevented by installed works of improvement	$15,575,000	$1,170,000	$511,000	$4,950,000	$22,206,000

Soil Conservation Service,
Watershed Operations Division,
July 1972

GEOLOGICAL CHARACTERISTICS

GENERAL

Many of the observations made, particularly with respect to sediment transport, can be explained in terms of the nature of the geological deposits that exist in the area and the ability of these deposits to absorb and transmit water. As a result, it was considered essential to the study that some background of the geology of the area particularly with respect to glacial geology as it affects drainage patterns, and fluvial sedimentation as it affects stream degradation and aggradation, be included

GLACIAL GEOLOGY

The portion of the flood area in southern New York and northeastern Pennsylvania is underlain by glacial deposits which have an effect on drainage patterns, storage and release of water, and availability of sediment. Most significant are the glacial outwash deposits of sand and gravel up to several hundred feet thick deposited by meltwater streams Much of this outwash material was deposited as terrances along the Susquehanna by meltwater floods. The fact that the logitudinal gradients of the terrances are essentially parallel to modern flood crest gradients suggest that these glacial floods were similar, in some respects, to modern floods (Peltier, 1949)

In some places the present Susquehanna River flows over a buried valley deepened by glacial scour and subsequently filled with glacial outwash material. For example, in Wyoming Valley where the most extensive flood damage occurred during the 1972 flood, the Susquehanna Valley is underlain by a buried valley up to 300 feet deep filled with sand and gravel

In addition to stratified sand and gravel outwash deposits, much of the glaciated portion of the Allegheny Plateau is underlain by unstratified glacial till deposited directly by the glaciers. In northeastern Pennsylvania, glacial till has an average thickness of 15-20 feet but may be up to 100 feet thick or more in filled depressions

Another deposit of glacial origin common over much of the northern Susquehanna Valley is fine silt deposited by winds blowing off glacial ice These silt deposits, called loess, may be up to 200 feet thick but arc usually more thinner (Peltier, 1949).

The 1972 flood left sediment deposits of mostly sand and gravel in the northern Susquehanna Valley. Along the Genesee River, it was reported that stream sediments were definable by three distinct layers, organic material from top soil, silt and gravel which has previously underlain the topsoil and silt.

The most direct effect of glacial deposits on the hydrology of the flood area is best shown by comparing the glacial map of the area (Fig 3) with the ground water map of Pennsylvania (Fig. 4) From these maps it is quite clear that the large yields of ground water in northern Pennsylvania are derived from glacial outwash deposits These deposits provide tremendous reservoirs for storage and release of water to streams much in the same manner as a sponge. In southern New York and northeastern Pennsylvania, ground water in permeable glacial deposits is the principal source of water for most lakes and streams (Lohman, 1937).

Much of the intense flooding can be explained by the fact that the storage capacity of the glacial deposits had been mostly used up during the rainy period before the Hurricane. Therefore, runoff occurred much sooner and more intensely than it would have if the storage capacity had been available.

DRAINAGE PATTERNS

The marked differences in geologic structure between the northern (Allegheny Plateau) and southern (Appalachian Mountain) portions of the area affected by the 1972 flooding result in differences in drainage patterns. These differences are illustrated in Figure 5 which shows portions of the Susquehanna River drainage basin in southern New York near Endicott, New York and in southern Pennsylvania near Harrisburg, Pennsylvania. The drainage in southern New York is developed on flat lying Devonian sandstone and shale covered, in part, with glacial drift. Note that the drainage here has developed a distinct branch-like pattern, essentially devoid of structural control and with relatively long segments of second and third order tributaries. In most of central and southern Pennsylvania streams are very definitely controlled by geologic structure, being confined mainly to narrow valleys between folded mountains of the Ridge and Valley Province (Fig. 6). Note that secondary tributaries are very short and there are very few third order tributaries. Such differences in drainage pattern will undoubtedly have an effect on drainage characteristics, especially on the lag time between runoff and flood crest.

FLUVIAL SEDIMENTATION

Figure 7A shows that a non-meandering stream consists of three areas of sedimentation: 1) the main channel filled with relatively coarse material, 2) natural levees of finer material deposited during a flood as the water leaves the confines of the channel, and 3) relatively fine-grained flood plain deposits. Figure 8 shows that for a meandering stream, the deposition pattern is modified by erosion on the outside of the meander and deposition of point bars on the inside of meanders. Because most streams do meander, their flood plains are really a complex of two depositional regimes: 1) true overbank deposits deposited during a flood and 2) areas built up on the insides of meanders by successive point bar deposition.

Consider now the effects of flood control measures by construction of artificial levees or dikes. The effects on the non-meandering stream depend on whether the stream is aggrading or degrading. The terms aggradation and degradation refer to whether the stream is undergoing net deposition or net erosion on a long term basis. The terms scour and fill apply to short term erosion and deposition which are usually averaged out. For example, most streams scour their channels during flood but the channels are subsequently filled to a point of preflood equilibrium. If a non-meandering stream is degrading, that is, eroding its channel on a long term basis, then the net effect will be to increase the distance between the stream bed and the top of the artificial levee (Figure 7C). However, if the stream is aggrading, the net effect will be eventually to decrease the distance between the stream bed and the top of the levee to the point where it will be necessary either to increase the height of the levee or to dredge the stream (Figure 7B)

In the example of the meandering stream (Figure 8), the same problems of aggradation and degradation apply but the situation is complicated because of the difficulties associated with bank erosion. For example, much of the damage which occurred in 1972 on the west bank of the Susquehanna River in the vicinity of Wilkes-Barre, Pa. was the result of the river undercutting the flood control levees on the outside of a meander in the town of Forty-Fort, Pa.

Note: Figure 3, Glacial Deposits contains an error. The dark green portion of the figure should be labeled Lacustrine Sediments and the blue cross-hatched section should be labeled Drift of Illinoian Age.

SOIL EROSION AND SEDIMENTATION

EROSION

The effect of the heavy rains as a result of Hurricane Agnes led to large amounts of agricultural upland sheet and gully erosion, streambank erosion, flood plain scour and flood plain deposition In Pennsylvania alone the U S D A Soil Conservation Service has estimated that 819,825 acres of agricultural land were subjected to sheet or gully erosion, 126,741 acres of flood plain were subjected to scouring, 97,351 acres of flood plain were subjected to deposition of sediment and gravel (See photos, this section) In New York State a similar situation was encountered only on a slight small scale. In the Genesee River Basin alone approximately 9,500 acres were inundated with heavy siltation having occurred over some 2000-3000 acres of flood plain lands. In the Chemung River Basin similar erosion and sedimentation problems were observed. (See photos, this section) Virginia lost approximately 50 million tons of topsoil from 1,100,000 acres of cropland not protected by adequate conservation practices (See photos, this section)

The problems encountered with regard to erosion of agricultural land were not limited solely to the flood plains In an overflight of agricultural areas in the fertile Finger Lakes Region of New York State, it was observed that possibly as high as 1% of upland agricultural land was subjected to gullying. In Maryland the estimates for the silt deposited and topsoil lost in the three major basins, the Patapsco, Potomac, and Patuxent River Basins, were approximately 100,000 and 200,000 cubic yards respectively.

Outside the actual transport of the three types of silt matter: stone and gravel, sandy silt, or organic and humus material, there were effects which may have occurred related to the chemical composition within the transported and residual soil. In the southern New York and northern Pennsylvania plateau region, the stream deposition was mainly of a sandy and fine gravelly nature as a result of the rock underlying the plateau consisting of weak, resistant sandstone and shale. South of this plateau, the underlying rock structure is metamorphic and igneous in nature The result was deposition of much coarser gravel in the southern region.

NUTRIENT LEACHING

Nitrogen leaching due to excessive quantities of water filtering through the soil left a good deal of the upland and flood plain lands nitrogen-ooor. This has a serious effect on the agricultural lands Farmers will have to refertilize their fields, possibly in tremendous quantities, to return the nitrogen lost

In addition to the leaching of nutrients from cultivated areas, one would also expect the leaching of various chemical genocides which may have been carried downstream by the high waters or silt movement. Herbicides used to kill undesired weeds and/or members of the grass species upstream, may result in the failure of grass crops and slower growth rates for river bank vegetation for the next few years downstream

SPECIES DISRUPTION

One of the more unique possibilities with regard to possible ecological disruption, lies in areas where a particular species of plants may not have been abundant. As a result of the flood, seeds may have been carried downstream and deposited in areas where species did not previously exist This may well result in a disturbance to the established balance If the spores of upstream vegetation find themselves in agricultural areas, economic pressures due to the presence of competing undesired vegetation may require the farmer to utilize more herbicides creating a worsened agricultural runoff situation

The heavy rains and flooding to some extent left their mark on the microbial populations within the soil Certain types of nitrogen-fixing bacteria as well as other large molecule hydrolyzing species and in addition nutrients, herbicides and pesticides may very well have been washed along with the finer soils This will most certainly have some ramification on the growth of smaller vegetation and agricultural output over the short term The long term effect due to the loss of microbial populations should be largely temporary in nature. Using the existing microbes, population distributions should reestablish themselves fairly rapidly to minimize intermediate and long term effects.

One of the larger problems induced by the floods and associated rains was that of loosening the bond that existed between the topsoil and the subsoil As a result, the soil retention capabilities have been altered due to the loss of vegetation and density distribution soil binding. It is likely that the erosion that has occurred will lead to future erosion and even greater loss of soil from even relatively minor rainfalls

In general, the effects of erosion and subsequent deposition on fields and streams will depend on the nature of the soil. In areas where the subsoil is poor or non-existent the period of recovery may be decades.

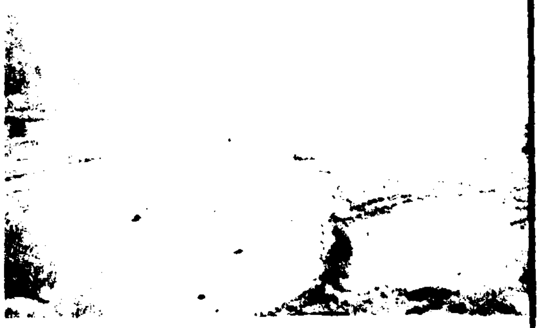
At this point with little or no analytical measurements available, it is hard to project future results and hence the magnitude of the soil erosion and deposition problem

FISHING CREEK, PA.
DELTA FORMATION

PAINTED POST, N.Y.
TREE NURSERY INUNDATED

CHEMUNG RIVER NEAR WAVERLY, N.Y.
EROSION TO FLOOD PLAIN

WICONISCO CREEK, PA.
EROSION TO AGRICULTURAL FIELD



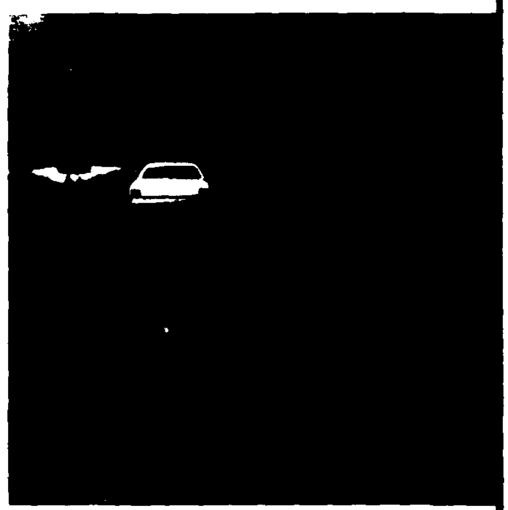
CHEMUNG RIVER, N.Y.
SILT DEPOSITION

JAMES RIVER-GLASGOW, VA.
FLOOD PLAIN SILTATION

BUFFALO RIVER-NORWOOD, VA.
FLOOD PLAIN EROSION

BLOEDES DAM-PATAPSCO RIVER, MD.
SILTATION

PATAPSCO RIVER
ELLICOTT CITY, MD.
STREAM BANK EROSION



PATAPSCO STATE PARK, MD.
SILTATION

O'BRIEN & GERE
ENGINEERS, INC.

TREE DAMAGE

GENERAL

In this section tree damages and timber losses are discussed Information on this subject was obtained from state forestry departments and state park commissions in New York and Pennsylvania and from several municipal, county, state and federal sources in the southern states area In very few instances were there estimated quantities of tree damages However, since the overall magnitude of tree damage was small, it would seem that numerical quantities are less important and that the intensity of the damage in a localized area is the prime concern

Within the entire study area the timber loss was generally described as negligible The people interviewed specifically for the determination of tree damage were mostly concerned with the commercial value of timber However, other interviews revealed that localized tree damage had certain effects on other environmental aspects

Timber damages and losses were for the most part located along the flood plain of the main streams and their tributaries and were caused by such phenomena as high velocities, high ground water tables, soil erosion of tree root systems and high dissolved solids content in the flood waters In many cases, where flood plains are confined and stream velocities did not decrease a great deal once the stream has overflowed its banks, the top soil around the trees was eroded away and the trees were left very susceptible to high velocities In other cases it was evident that high stream velocities were the sole contributor to trees having been damaged (see photos, this section)

Many trees within the flood plains were inundated for several days before the water receded within the banks of the normal stream channel Some of the older trees survived; however, there is now evidence that some of the younger, previously inundated trees are now dying (See photo, this section) The specific cause of this type of tree death can be associated with either a drowning of the trees or excessive levels of dissolved solids which can be lethal

The ecological impact of flood plain tree damage is long term The types of trees affected were non-valuable in a commercial sense, e g willow, cottonwood, sycamore, river poplar and many elm that were already dying from the Dutch Elm disease These trees, however, are quite valuable to a stream in that the banks are rendered more stable and erosion is limited a minimum during high flood periods They also shade several areas of the stream which become places where fish tend to feed

Tree damages also affect the wildlife that exist in and around water bodies Trees serve as protection to birds such as quail and turkey, ground nesters such as moles and mice and large game animals such as deer Direct effects to wildlife are discussed in the wildlife section of this report

A "girdling" effect may also have been felt by some trees on the flood plains where sustained inundation occurred The bark on some trees may have been damaged below the water line resulting in the tree trunks being exposed to the weather and/or insects and tree diseases when the waters receded No specific cases of this nature have been reported, but it is possible that such a girdling effect did occur in some areas

Most upland tree damages fall into the category of mud slides These trees were mostly hardwood, but there were so few losses that the total effect, both commercial and ecological, is considered negligible

Synopsized below are specific examples of tree damage

ALLEGHENY NATIONAL FOREST, PENNSYLVANIA

It was reported that the water level behind the Kinzua Dam nearly reached a one in one-hundred year level The effect of this high water level was to flood the area adjacent to the Allegheny Reservoir There was two major landslides destroying several acres of hardwood trees and a total of 2,000 acres of forest land inundated

There was also inundated of 1,400 acres of forest land behind the Tionesta Reservoir which is located on Tionesta Creek before it empties into the Allegheny River

SENECA FALLS, NEW YORK

There were approximately 4,500 acres of inundated swampy areas in this location Since most of the timber is readily adaptable to wet conditions, it appears that only the younger trees may have been drowned by the long period of inundation Specific types of trees include white oak, ash, red maple and elm

BRISTOL MOUNTAIN, NEW YORK

A mud slide occurred on the western side of Bristol Mountain which is located west of Canandaigua Lake There was an estimated 7 to 10 acres of hardwood timber lost due to the slide

HERNDON PENNSYLVANIA

A significantly large mud slide occurred on the edge of a highway near Herndon Several acres of hardwood were lost and an immediate danger to traffic and housing in the area was evident (See photo, this section)

SCHICKSHINNY, PENNSYLVANIA

Two small mud slides occurred within one mile of each other on the Schickshinny Mountain The effect of these slides is insignificant in both the commercial and ecological impact sense

LYKENS, PENNSYLVANIA

Along Wiconisco Creek in Lykens, a number of trees were killed by flood waters carrying a substantial amount of mine waste (See photo, this section)

VIRGINIA AND MARYLAND

Most of the damage to trees in Virginia and Maryland occurred along the James River and Patapsco River, respectively. (See photos, this section). The speed and force of the flood waters caused severe tree damage along the stream banks. At Smith Mountain Lake, Virginia, high waters and violent wave action also resulted in tree damage (See photo, this section)

POTOMAC RIVER, MARYLAND

The U S Department of Interior, National Park Service estimates that over 200,000 large trees were lost along the river banks and flood plains of the Potomac River.

GENESEE RIVER, N.Y.
TREE INUNDATION-NOW
CAUSING DIE OFF

MOUNT MORRIS DAM
GENESEE RIVER, N.Y.
DAMAGED TREE ACCUMULATION

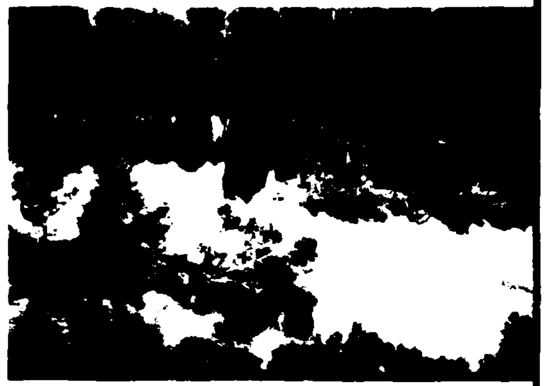
SUSQUEHANNA RIVER, PA.
TREE LOSS DUE TO HIGH VELOCITIES

WICONISCO CK.- LYKENS, PA.
TREES KILLED BY MINE WASTE
FLOOD WATER

HERNDON, PA.- MUD SLIDE

O'BRIEN & GERE
ENGINEERS, INC.

JAMES RIVER- RIVERVILLE, VA.
TREE DAMAGE
AND FLOOD PLAIN EROSION



JAMES RIVER- WARREN, VA.
TREE DAMAGE

SMITH MOUNTAIN LAKE, VA.
TREE DAMAGE

PATAPSCO RIVER, MD.
TREE DAMAGE

PATAPSCO RIVER, MD.
TREE DAMAGE AND SILTATION

WILDLIFE AND RELATED HABITAT

GENERAL

There are two principal effects of the hurricane to consider: the flooding and the prolonged rains. The floods destroyed any wildlife in their path. Thus young of species nesting in the flood plain were drowned as were species unable to move quickly out of the way. The prolonged rains affected wildlife in three ways: young in nests that will hold water were drowned or died from exposure, and species which feed on flying insects starved in large numbers.

As soon as the waters receded and the rains stopped, it is safe to assume that certain wildlife species began to build up again. In some places, the species composition will be different, at times drastically, from what it was prior to the flood. However, with time this difference may decrease. The factors tending to increase the degree and the duration of this change are: the maturity of the habitat affected, the extent of the physical destruction of plants, and the amount of siltation or erosion. Thus, if a mature forest were totally destroyed and the soil washed away, the wildlife in the locality would not be the same again for many decades, and might never be. On the other hand, a grassy river bank which suffered only minor siltation might re-establish itself in a few years and support a wildlife composition very similar to that which occurred prior to the flood.

In general, the species which are rarest, non-migratory, and nearest the top of the food web, will take longest to establish themselves. Insects and other invertebrates will very quickly return whereas the larger carnivores, which are usually near the top of the food web, and especially those which are uncommon such as certain of the hawks and owls and carnivorous mammals, may take longer to become established.

The result of the flood and the rains should be viewed as a change in wildlife composition not simply as the destruction of wildlife. To view the flood and rains simply as an agent of destruction is to ignore the virtual certainty that animals will rapidly invade again and establish themselves. However, predictions about the absolute time or conditions needed for a species to re-establish itself can be made only on a case by case basis and for the large, uncommon carnivores will probably be difficult anyway.

BIRDS

The succession of low temperatures throughout June, rain in the fourth week, and then the floods, combined to produce a degree of avian (bird) mortality that has seldom been equaled in the last few centuries. Although most adult birds were able to escape flood waters, many nests with eggs or downy young were inundated and thus destroyed. In addition, within areas of prolonged rain, many adult birds of smaller species, and probably the majority of nestlings, perished. Though nestling death was primarily due to exposure, drowning of young in nests capable of containing water, and starvation among those species dependant on flying insects for their food, were also important causes of avian mortality.

Waterfowl, since they breed largely within the flood plain, were severely affected if their eggs had not hatched In the southern portion of the study area, roughly south of Pennsylvania, most of them had already raised their broods beyond the danger point In the north, however, they tended to fare less well. Montezuma National Wildlife Refuge, in central New York, reported a 75% loss of brood production However, only four species of waterfowl nest throughout the study area: Mallard, Black Duck, Wood Duck, and Hooded Merganser. All of these birds have large breeding ranges outside the study area and are migratory, thus capable of re-invading an area if their numbers were drastically reduced within it.

Game birds too may have died in considerable numbers, though from a different cause. Although any nests in the flood plain were certainly destroyed, the major cause of death throughout the area was probably exposure, not drowning. Young of most game birds are highly susceptible to chilling. Consequently, in areas of prolonged rain, game bird production this year may have been largely the result of re-nesting among the Ruffed Grouse, Turkey, and Ring-necked Pheasant and of second broods among the Bob-white, the only game bird in the study area that commonly has multiple broods each season

There are little quantitative data available with which to estimate the population reduction Members of the Pennsylvania Game Commission listed Turkey, Pheasant, and Bob-white slightly less common this year than last based on casual sighting after the hurricane If the populations are only slightly decreased, there is probably little cause for concern On the other hand, these birds are non-migratory; if their numbers turn out to be extremely low, some thought may have to be given to restricting the hunting season next year.

The most serious instances of domestic fowl mortality yet reported were directly attributed to flooding The Lowalsock Pheasant Farm in Montoursville, Pennsylvania lost approximately 35,000 birds The State Wild Turkey Farm at Barbours, Pennsylvania lost most of its males, many of which were the result of over 100 years of selective breeding. New birds have since been purchased from private game farms

Among the herons, hawks, and shorebirds, no records of extremely serious mortality have been received Badly damaged colonies of Black-necked Stilt at Little Creek, Delaware, and of Cattle Egret on the Susquehanna River near Harrisburg, Pennsylvania, both probably represent the northern breeding limits for these birds and are thus of interest to ornithologists However, they may well return next year and in any case there is little man can do to increase the chances of a successful breeding season next year. A severely damaged Brown Pelican colony at Okracoke Inlet, North Carolina is mentioned here even though it is outside the study area because of the much publicized decline of this species during the last few years.

Most of the gulls, terns, and sea birds nest outside the study area However, one report from Robert Teulings in American Birds is of interest and suggests the need for further checking on coastal species He notes a "significant disruption of nesting of colonial species as far south as Charleston, South Carolina, with production of Least Terns a vertual failure in the affected areas. Gull-billed Terns and Black Skimmers apparently were also hard hit, but most of the other colonial nesters did manage to re-nest successfully "

A colony of several hundred Common Terns on Oneida Lake in Central New York nested very late due to high water all spring There were fewer eggs than in the last few years but hatching and fledging appeared to be quite successful

The most devastating effects probably occurred among those species which feed on flying insects. The swallows, Purple Martin, Chimney Swift, and Common Nighthawk all depend heavily on insects and several of these species are cavity nesters Thus their young were exposed to lower than normal temperatures, standing water in the nests, constant rain, and severe if not total food shortages Maurice Broun, writing from New Ringgold, Pennsylvania, tells of "a huge martin colony in Lewiston Valley so decimated that only a handful of birds survived An intensive Purple Martin survey on the Ohio River from Sisterville, West Virginia to Racine, Ohio ascertained that 1,110 adults, 416 young, and 59 eggs, were destroyed, presumably by the hurricane. Dr George Hall writes that "it is safe to conclude that at least 90 per cent and at many places 100 per cent of the Purple Martin nestings as well as many adults in the western half of Pennsylvania died" At Charleston, West Virginia, there is a major gathering place for southbound martins. It was estimated that the total population this year was one third the normal and that young birds were reduced 80-85 per cent These reports and many others like them make it clear that Purple Martins at least, and perhaps most of the flying insect eaters, sustained a very heavy mortality

Since many of these birds only live for one breeding season, this population reduction could have a lasting effect. Although the prediction of one observor that it will take Purple Martins twenty years to recover should be viewed more as speculation than as scientific deduction, ornithologists across the northeast will be watching next spring's Martin arrival with some anxiety If the population of martins or other flying insect eaters is low enough, some consideration should be given to adjusting insecticide spraying programs so that flying insects are not destroyed just when these nestings need the greatest amount of food.

Other small birds, particularly ground nesters, may have suffered heavily However, since their nests are not as readily observable as those of the martin, it is difficult to evaluate the hurricane's effect Bird banders' reports may show a decrease in migrating young but will not be available until early in 1973 Singing male counts next spring will also give some indication of whether there has been a drastic reduction of any species. At the present, however, there is no firm evidence to report.

Aside from the instances noted, few suggestions were received of measures that should be taken to ameliorate the hurricane's effects on birds. These species have evolved over many hundreds of thousands of years On this time scale, disasters such as the one under consideration are generally insignificant; species not able to rebound have long since become extinct Thus most observors feel that even those species which suffered heavy mortality will increase again within a few years Furthermore, they point out that our knowledge of ecology is rudimentary at best and that, therefore, any mangement attempts we make with exception of the few mentioned above, might well do far more harm than good

MAMMALS AND OTHER WILDLIFE

Any wildlife unable to move quickly out of the flood plain was probably drowned. Besides affecting small animals such as mice, snakes and perhaps even some amphibians, larger animals were killed in some instances A few fawns and five to ten adult deer carcasses were found in north-central Pennsylvania after the flood waters receded. At the Caneadea Dam in Caneadea, New York, fifty deer carcasses were found at the base of the dam, apparently trapped by rapidly cresting flood waters. These instances are the exception rather than the rule, however, and probably have little effect on the overall population. One exception could be islands that were covered with water. Except for birds and aquatic species, all wildlife was probably drowned. It may take considerable time for some of these islands to re-populate, particularly with larger animals that are inactive in winter such as the Woodchuck, Eastern Chipmunk, Raccoon, and Striped Skunk.

Most mammals were probably not as seriously affected by the prolonged rains as some of the birds. Bats may be an exception since they feed primarily on flying insects and typically raise only one or two young per year But, most of the species are either large enough to withstand adverse weather or breed prolifically and would thus soon recover even if they were drastically reduced

The small mammals that feed on grains are in this class. Their populations will build up again far more quickly than their natural predators Until their predators restore the natural balance, they could be a more serious problem to the farmer than they were before the flood

This investigation did not include a special attempt to discover severe effects on reptiles, amphibians or other animals No notable instances were uncovered in the course of the study.

HABITAT

In general little permanent damage to wildlife habitat was caused by the flooding. Although many of the food sources in the flood plain were affected by excessive inundation or washing out, they will probably recover fairly rapidly There may be a succession of stages in some areas of heavy siltation. For the first few years weeds and brambles, and the wildlife wwhich depends on them. will thrive Gradually brush and scrub growth will replace the weeds bringing with them a new wildlife composition and eventually the area will be invaded by trees if not disturbed This process may be particularly noticeable in the Genesee River Basin where approximately 9,500 acreas were inundated.

In northwestern Pennsylvania, food sources for domestic animals were hit extremely hard. Most hay crops were either washed out or drowned If the crops were not destroyed, the excessive dampness hampered harvesting Therefore, there may be a critical shortage of cattle food this winter and an abundance of alfalfa for deer and rodents along the southern tier in New York and Pennsylvania

In this study area there are seven (7) National Wildlife Refuges, primarily for migratory birds. In addition, there are many state wildlife refuges which serve as bird sanctuaries as well as educational centers in many cases. Some of these sustained physical damage such as the Montezuma National Wildlife Refuge which reported $60,000 damage to dikes, blinds, and crops.

IMPACT ON WILDLIFE

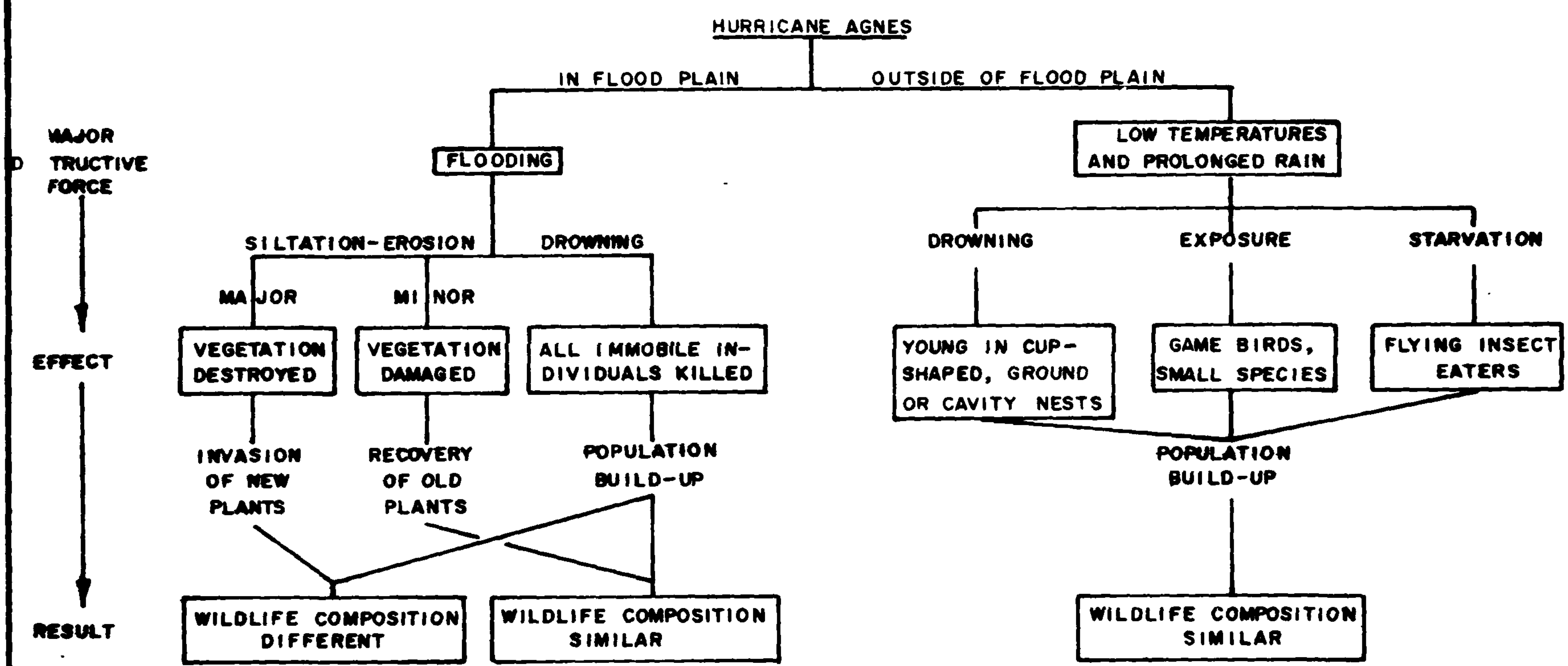


TABLE 2

FISHLIFE AND RELATED HABITAT

EFFECTS OF FLOOD CONDITIONS ON FISH

Few studies have been undertaken specifically to show the effects of flood conditions on fish populations Usually observations concerning effects of floods are reported because such conditions occur during a project already underway Because of the lack of specific information on flood effects, it is necessary to use results from projects concerned with environmental conditions that are similar to the after effects of floods

Determining how the fish react to increased discharge and the effects on the fish caused by extensive changes in habitat requires the simultaneous study of many parameters These include observations on changes in physical and chemical conditions of stream water, as well as on changes in intricate biotic factors such as food availability, population density, breeding conditions and behavioral patterns The interrelationship of these factors is illustrated in Table 3.

In most cases, it is normal for fish populations of streams to be exposed to fluctuations in discharge rates throughout the year. It is an unusual situation to have such high currents and discharge rates that fish populations are eliminated completely However, changes in the stream bed, turbidity, quantity of cover, and eroded materials will affect the remaining fish as well as making it difficult for recolonization of the stream from nearby populations When a reservoir of fish is available and habitat conditions are suitable, recolonization by most species will be done in a few weeks If the stream bed has been altered extensively, by the flood or by cleanup procedures, to the point that shallow pools with little running water are abundant, migratory movement by the fish will be hampered stopping recolonization and normal movements to deep water in winter or upstream in spring (see photo, Conclusions and Recommendations Section)

The shape and behavior of stream fish aid in their adapting to flowing water conditions Top fish such as trout, walleye and salmon, or those moving throughout the water column, are most streamlined in shape and are strong swimmers. Bottom fish such as catfish, darters, suckers and sculpins lack or have reduced swim bladders or have specialized structures to help hold them to the bottom Even young salmon and trout, often found on the bottom of running water, have their fins orientated so the water moving over them will push them down

The normal reaction of fish is to face the current which aids in moving water over the gills to facilitate respiration. Although there is a tendency of many top fish to lift up in the water as current increases, maintaining position becomes difficult and they will seek shelter behind rocks or move to cover providing optimum conditions This has been indicated by observations on brown trout in an experimental flume. Top fish tend to maintain their position by sight reference to fixed points, whereas bottom dwelling fish maintain their place by physical contact with the substrate. Any factor which inhibits the use of these cues, such as increased turbidity, will affect the fish.

Fish unable to hold their positions in the normal stream bed may be pushed over the banks with the flooding waters or displaced downstream Certainly eggs and small specimens can be destroyed by high waters Some fish move into areas normally inundated by high waters of Spring to spawn In cases of abnormally high water conditions, individuals may move too far and become isolated when flood waters recede

There is a direct result of increased discharge in producing physical damage to fish and stream invertebrates by tumbling and moving rocks and debris. Heavy small particles may act as an abrasive Under conditions of less discharge such material would not be held in suspension. Many species of fish can withstand high turbidities but their gills may become clogged causing suffocation

Although the high quantity of suspended materials during flood conditions would not normally affect the larger fish, they do affect the stream habitat As the turbulence lessens with decreased discharge, the heavier particles fall out of suspension providing a layer of material on the stream bed If this layer covers riffle areas or gravel substrates, breeding grounds and normal feeding areas and territories may be lost to the fish In some cases the scouring action of flood waters may have cleaned out silted areas of streams making them more habitable to fish In rivers and streams the greatest numbers of specimens and species are usually associated with beds of gravel and sand, and definite species associated with riffle areas are known The light particles that will stay in suspension for a long time will decrease light transmission through the water This will have an effect on the growth of aquatic plants that provide cover, food, substrate stabilization and add oxygen to the water

Due to erosion, turbid water and siltation may continue for some time after floods have ceased if stream side vegetation were washed out or depleted during clean up Situations of serious silting and reduction of fish and invertebrate populations because of soil erosion have been observed from logging operations and from highway construction In cases where stream side vegetation has not recovered, heavy rains or light flooding later in the year may cause even more damage due to erosion than the primary flood

Runoff from heavy rainfall may contain large quantities of dissolved materials depending on the type of watershed Unless toxic chemicals were present in the drained areas, damage to fish probably would not occur However, large quantities of nutrients may be made available which would enhance plant growth or make the environment more favorable for undesirable plant species The effects of enrichment are well known for lakes but not streams Most often stream enrichment is complicated because of organic pollutants In any case, if shade is lacking, more sunlight will be available for plant production as turbidity is decreased

The lack of stream side vegetation that would normally shade portions of the water produces two quite different problems for the fish and stream bed organisms. First, because the stream will be subject to more sunlight, the water temperature will rise as much as 12°F over short distances Most fish are able to withstand maximum seasonal temperature variations, to which they are exposed Bottom forms are capable of withstanding higher temperatures (30-33 C) than trout or pike (24-29 C) Even though temperatures may not be lethal, a change may interrupt or cause premature breeding, affect growth rate or produce unusual migrations or movements from their natural habitat as has been indicated for trout

Higher temperature also means less oxygen is going to be dissolved in the water and because of the warmer temperature, the oxygen consumption by fish is going to be increased According to one study, 100% oxygen saturation of the water is necessary for full activity of brook trout at 20°C If decreases in oxygen concentrations occur in the fish breeding ground areas, embryonic development may be slowed or stopped Such development seems to be closely correlated with temperature, dissolved oxygen and current Reducing the stream bed to shallow pools, as happens during drought or possibly in reclaiming stream beds after high water, also affects the fish Such pools usually have high temperatures, low quantities of dissolved oxygen and concentrate the fish making them easily accessible to land predators Whether such aggregates of fish would be more susceptible to disease and parasitic infestations is a matter of conjecture

The second possible effect of stream side vegetation reduction is to cause a behavioral change in the fish in response to changes in sunlight duration and cover It has been shown that removal of natural cover will decrease trout populations Many species of fish show diurnal feeding or activity patterns that are interrupted by lack of cover Such has been shown for yearling rainbow trout The effect of changed activity or feeding periods may be quite subtle involving the competition of one kind of fish with another for a certain type of food or territory

Territoriality is usually a fish behavior common during breeding season but it is also evident in many stream species under non-breeding conditions Young trout are territorial in shallow rapids but will move into groups when in pools or back waters. A territory consists of an area that provides cover for a fish and it might be said that the more large stones the more territories available Flood situations that reduce the territories reduce the possible number of fish that can inhabit an area Competition for the territories will probably be in favor of the residents when restocking is tried

A balanced population of two fish species in the same habitat can be upset by flooding situations and thus change the competition An example was reported by Seegrist & Gard from a 10 year study Winter floods decimated developing eggs of fall spawning brook trout thus reducing competition with spring spawning rainbow trout The reverse was true for spring floods and such changes in species composition endured for several years

Of major importance to maintaining a healthy fish population is an adequate food source Most stream fish species some time in their life cycle utilize the invertebrate organisms located in the substrate Invertebrates in the stream are influenced by floods in much the same way as has been indicated for fish

In a study of a Utah stream that was completely cleaned out by an August flood, benthic organisms were present a month later Midge and black fly larvae were present soon after flood waters receded whereas mayfly, caddis fly and stonefly nymphs reappeared more slowly As with fish, change of substrate or other environmental factors may prevent invasion by certain species of benthic invertebrates. Certainly a decrease in fish food is going to affect the growth rate of the fish using them for food as has been documented for brook trout It required two years for the growth rates of fishes and population sizes of benthic invertebrates to regain preflood conditions Not all fish use the benthic invertebrates exclusively for food Trout takes great quantities of food at the water surface during the summer so that 40-50% of its food may consist of terrestrial insects Also terrestrial organisms may be deposited in streams during high water stages and be used as food by the fish

ECOLOGICAL EFFECTS OF HURRICANE AGNES ACCORDING TO QUESTIONNAIRE REPLIES

Replies from questionnaires concerning impact of Hurricane Agnes on fish life are sparce Most of those individuals or agencies responding were in the state of New York These included the Tioga, Broome, Cortland Cayuga, and Seneca Counties representing the central part of the state and the Genesee River Basin in the northwestern part of the state There were also observations reported from the Chautaugua drainage basin

In general these reports indicate that the floods caused by Hurricane Agnes did short term damage to fish by destroying eggs and young fish This may result in an age class of fish missing as indicated for rainbow trout in the Chautauqua and Genesee area Adult fish were probably not as extensively damaged, although estimates from Cortland County, New York indicate 50-75% reduction of large rainbow trout which may lead to the disruption of breeding runs during the spring Where estimates were made, it was expected that it would take at least two years to bring fishing to what it was before the hurricane

Whereas it was obviously difficult to report on direct effects to fish life, all reports mentioning effects on fish emphasize habitat disruption and place more importance on this than on short term destruction The reports mention silting of rapids, filling in of pools and the possible effects of the removal of stream side vegetation These situations were reported caused by stream channel restoration projects in western and central New York, as well as by the flood

Also the possible effects of erosion, producing turbidity, as a continuing problem until cover is replaced was mentioned Reports from the Chautauqua area state that the most serious problem for fish will be the warming of water temperature due to loss of overhead cover In reference to the dissolved oxygen-temperature relationship, observations from the Genesee River Basin indicate that stream waters before storm had high dissolved oxygen, low turbidity and many trout; after storm had lower dissolved oxygen, high turbidity and few fish; and as of August 28, 1972, medium dissolved oxygen, medium turbidity and few fish

A rather unusual problem was reported from a wildlife refuge area in Seneca County, New York The inundation of the refuge area by water from flooded streams brought with it carp and bullheads These fish have kept the waters turbid and stirred up by their feeding activities to such an extent that plant growth is reduced because of lack of sunlight Loss of aquatic vegetation will have a detrimental effect on waterfowl in the refuge

In addition to the ecological effects of high discharge rates, facilities located on stream and river sites such as fish nurseries and hatcheries may be hard hit by unusually high waters Such was the case from the effects of Hurricane Agnes Many fingerlings that would normally be used for restocking were washed from their holding ponds and probably destroyed along with the resident young fish The Pennsylvania Fish Commission estimates that 5% of their trout fingerlings, yearlings and brood stock were destroyed. One estimate of Pennsylvania trout hatchery losses placed the fish destroyed equal to $37,500. A monetary estimate of the other hatchery fish that were lost is incomplete. (These figures do not represent cost estimates of the damage to physical facilities.)

Although most of the significant data were collected from the New York and Pennsylvania interviews, it seems reasonable to assume that fishlife in the Maryland, Virginia and West Virginia streams would be affected much in the same manner. Aggradation and degredation occurred similarly in the southern state areas as in New York and Pennsylvania.

IMPACT ON FISHLIFE

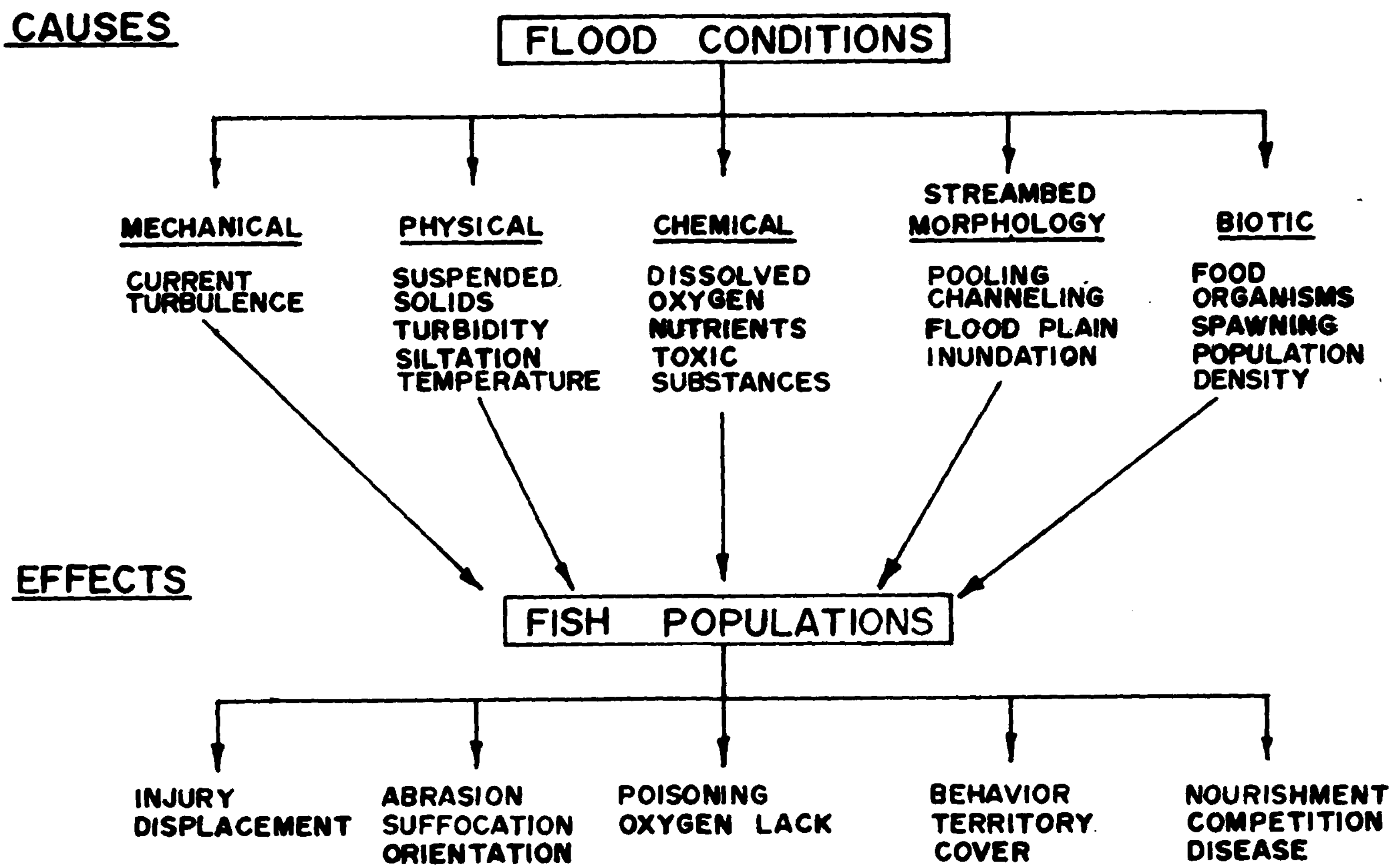


TABLE 3

WATER QUALITY

GENERAL

The impact on water quality can be considered to be to some extent attributable to pre-flood high ground water tables in that many materials were more susceptible to washing from flood conditions. Most of the impact, however, is attributable to the flood conditions.

The health departments of the areas involved were immediately concerned with the quality of the water courses as they related to food sources and water supplies. The departments of conservation are interested in the long term effects of water quality on the ecosystem but water quality surveillance network information has not yet been evaluated. It is anticipated that the required data processing will be completed sometime following this report. In the case of Pennsylvania the water quality surveillance network operation was disrupted due to emergency operations. It is anticipated that the complete sampling program will be in operation at a more intensive level in the immediate future.

MINE WATERS

Data obtained from the Pennsylvania Department of Health on the Susquehanna River at various locations along its length showed significant increases in the concentration of a number of parameters between June 15, 1972 and August 8, 1972. Such increases are considered to lower the water quality of the stream. In the stretch between Danville and Wilkes-Barre, there is a significant level of mining activity within the basin. Over 200 mines in Pennsylvania alone have applied for discharge permits. A direct result of the heavy runoff was to fill the mines, with a resultant increase in the discharge of acid mine wastes, through both the normal mine outlets and by entering the ground water. Within the time frame previously mentioned there was observed a 25% increase in alkalinity, 42% increase in sulfates, 27% increase in total solids and a 19% increase in specific conductance. The large increase in sulfates was largely due to the increase loading of acid mine constituents. The increase in alkalinity may well have resulted from the scouring of benthic deposits and subsequent return of organic and inorganic agents of buffering systems to the aqueous phase.

In addition to the aforementioned water quality surveillance data obtained in the area bounded by Danville and Wilkes-Barre on the Susquehanna River, a number of readings were obtained from other water courses in Pennsylvania. These analytical data indicate a general increase in alkalinity, hardness, chlorides, sulfates, and phosphates following the flooding. The measurements were made roughly two months following the flooding and thus represent effects that are short term in duration. Since the complete compilation of information is not as yet available, the intermediate and long term effects can only be hypothesized.

HIGH STREAM VELOCITIES

In general, the immediate effect of the high stream velocities was to increase to relatively high levels, suspended, colloidal, and dissolved material. The initial high turbidities most likely had a serious short term effect on aquatic life High turbidities have been known to cause death to all species of fish due to the deposition of this colloidal and suspended matter on the opercular cavities and gills.

Such damage is related more to the type of suspended matter rather than the concentration For instance, studies (Jones, 1964) have shown yearling rainbow trout to be susceptible to wood fibres at 200 mg/l but not coal washings in equal concentrations Other tests have shown trout to survive concentrations of over 5,000 mg/l of gypsum In the absence of specific information on water quality during flood conditions, it can only be hypothesized that certain local conditions, i e culm piles (deposits of coal dust and silt), may have exceeded tolerable limits of suspended matter. Other forms of aquatic life generally are not as severely affected by high turbidities. Bullfrog tadpoles and crayfish, for example, can withstand over 150,000 units of turbidity without death It was observed that levels of suspended and colloidal material existed at very high levels for only a short period of time and mostly in the headwaters having high velocities

OIL SPILLS

The effect of Hurricane Agnes also resulted in oil spills to receiving streams in at least three locations The most significant of these losses occurred at Pottstown, Pennsylvania where a lagoon containing 8,000,000 gallons of crankcase oil awaiting reclamation, was inundated and flushed out of the lagoon by the high waters of the Schuylkill River At least 60% of the capacity of the storage lagoon was lost, spreading the contants over a 16 mile stretch of the receiving stream Fuel storage facilities at Richmond, Virginia and Big Flats, New York were ruptured as a result of the high velocity of flood waters The resultant losses of fuel oil had minor effects upon both the James and Chemung Rivers The effects of the oil losses with the exception of the Pottstown incident were most likely short term At the present time, studies are being conducted with regard to water quality and sediment composition downstream of the Pottstown spill It is likely that a large spill of this nature will have a pronounced long term effect on the benthic demand exerted in the low velocity sections of the river bed. There should result some medium duration effects upon aquatic vegetation and bed type aquatic life The immediate effect of the spill at Pottstown was a fish kill of undefined proportions in the Schuylkill River.

CULM PILES

Another interesting source of contamination particularly in specific areas in Pennsylvania and West Virginia was from the erosion and leaching from piles of mine tailings and waste materials into adjacent water courses In the area of Donaldson, Sheridan and Middleport, Pennsylvania, culm piles became saturated with water and were eroded away into the Wiconisco and Good Spring Creeks, approximately 100,000 tons and 160,000 cubic yards into each respectively. The normal effect of these piles is to provide a leachate low in pH and high in chemical oxygen demand to the receiving stream The streams in the vicinity of the culm piles generally have ph's as low a 3 5-4.5 With this material presently residing in the stream beds and localized in large quantities, (4' to 5' deep), there must have been an adverse effect on the stream such as a lowering of pH to extreme values.

AGRICULTURAL SOURCES

The effects on water quality of leached nutrients, herbicides, pesticides, and fungicides from agricultural applications most certainly would provide an adverse effect on water quality as a result of the flooding The effects can only be assessed by reviewing the results of the various state sponsored water quality surveillance networks. Some data have been compiled on eight streams in Pennsylvania which reflected a four fold increase in phosphate concentrations based on routinely collected quarterly samples obtained in the latter part of May and August (Pennsylvania Department of Health). Flood conditions will increase phosphorous released to the receiving streams over more normal agricultural runoff conditions The large increase observed is probably due to the siltation of stream beds with subsequent release of nutrients from the fertile agricultural silt. Any accurate correlation will require an evaluation of analytical results from more extensive data than are presently available

In a similar manner to what has been observed with phosphates, sediments of agricultural or fertile origin released fairly high levels of pesticides, herbicides, fungicides and nutrients. The clays and humus type soils commonly found in flood plain agricultural areas have a very large exchange capacity allowing the adsorption of chlorinated hydrocarbons, nutrients etc When these materials are deposited in the stream bed, they are released to the aqueous phase As a result, it would be anticipated that agricultural siltation should provide a slight to moderate impact on the water quality of receiving streams of unknown duration since this would depend on the physical, chemical and biological characteristics of the stream

On a short term basis, the very high agricultural runoff due to Hurricane Agnes, occurring at a time closely following heavy agricultural pesticide and nutrient supplement application undoubtedly resulted in a tremendous input of certain agricultural contaminants to the flood waters. The result of this leaching was mot likely of short duration with the largest percentage of the first flush constituents finding their way to estuary and bay environments. A certain small percentage of these contaminants most certainly found themselves incorporated into the sediment material to be discharged via slow diffusion and exchange release mechanisms

Another source of nutrients and agricultural biocide control agents was from the flooding of stock piles of these agents awaiting application Many farmers in the flood plain had storage facilities which were inundated, with subsequent release of these materials to the flood waters Of a larger individual concern was the flooding of an agricultural chemicals storage and distribution center in Elmira, New York. As a result of the flooding, pesticide cannisters were swept away as well as nutrient supplement materials. Little or no analytical data were obtained on the short term effects of the release of biocide control agents to the receiving streams State managed water quality surveillance networks generally do not include the measurement of chlorinated hydrocarbons, carbamates or organophosphorous compounds

It has been mentioned in the above section that agricultural chemicals most probably contributed in a major way to the quality of water courses during and following the flood There is a number of indirect causes of these materials finding themselves in the receiving streams There were cases recorded where materials destroyed by flooding were reintroduced to the receiving stream for means of disposal One particular documented incident involved dumping damaged insecticide and lime pre-treated seed corn into the receiving stream A good number of similar incidents may have occurred without being recorded

SEWAGE

One of the major effects on surface water quality was the extremely large amount of raw sewage and urban runoff bypassed to the receiving streams due to the extreme hydraulic loadings on the treatment facilities. Associated with this is the correlative breakdown of acclimated biological treatment systems due to physical hydraulic wipeouts, reduction of mixed liquor microbial populations and actual inundation of treatment facilities located in the hard hit flood plain areas Based on Damage Survey Reports for New York State alone, it was estimated that at least 2 5 billion gallons of municipal sewage were discharged directly to receiving streams which otherwise would have been treated by existing sewage treatment plants This estimate was arrived at by summing up the average daily capacity for all the treatment facilities in the affected areas of New York State and assuming that most of the sanitary sewage was bypassed for 5 days and that the facilities operated only a 50% efficiency during the ensuing ten days The average municipal sewage input as a result of the Hurricane Agnes was estimated to be 2 gal/capita/day The impact of this source will most likely be of short duration with the exception of that portion which might have become part of the benthic demand. Many sewer lines were also disrupted For example, in Baltimore, Maryland, 13,000 feet of 42-inch interceptor sewer line was broken resulting in 900 million gallons of raw sewage being bypassed The Jones Falls Interceptor also was broken resulting in 700 million gallons of raw sewage bypassed. The Gwynns Falls Interceptor also in Baltimore was broken in five places causing over two billion gallons of raw sewage to be bypassed

Such occurrences, although specific in the above cited cases, were very extensive throughout the flood area. Many sewers and sewage treatment plants were still not back in full operating condition Virginia estimates it will take up to one year to complete repairs in some plants

EFFECTS OF CLEANUP OPERATIONS

An "after flood" effect on water quality results from the channelization program currently conducted by independent contractors under the direction of the U S Army Corps of Engineers Although the channelization program is necessary to restore streams to their former hydraulic capacity, such "cleaning" operations have adverse effects on water quality and must be attributed to the "Agnes" flooding The channelization program causes great increases in turbidity downstream from the operations resulting in a serious change in water quality Disturbing the sediment also results in the resolubilization or buffering agents, nutrients, oxygen demanding materials, etc

To summarize, the effect of the flooding induced by Hurricane Agnes on the receiving streams were of two types, of short duration and heavy impact as well as of long duration and of less immediate impact For a period of 5 to 10 days following the initiation of the heavy rains, streams received a heavy loading of silt, gravel (see photos, Soil Erosion & Sedimentation Section), sewage, agricultural chemicals, nutrients, industrial wastes and other undefined potentially toxic inputs. This initial effect was to result in at least 90% of the fish kills observed, fouling of ground and surface water supply sources, impairment of the recreational usage from contact and non-contact activities, as well as impairment of the synergystic environmental relationships.

With respect to long term effects on surface waters, they should generally be lighter in impact. The effects of the deposition of nutrient rich agricultural soils, industrial soil and aqueous phase incompatible wastes, municipal sanitary orientated soil wastes as well as eutropment of water soluble components in the stream beds will exert a long term impact on water quality. This effect will be largely from a desorption of materials within the stream beds to surface water sources.

Ground water sources will likely be subjected to more serious long term effects that the surface waters previously discussed. This is largely due to the low transport capacities of ground waters. Ground water sources in a flood plain, particularly those near a potential point source of contamination such as the acid mine wastes in Pennsylvania, may be subject to long term water quality alterations. The nature of these effects will require long term monitoring in order thoroughly to assess the magnitude of the impact.

RECREATIONAL IMPACT

GENERAL

The nation's wildlands and outdoor areas serve as a major recreational outlet for the increasingly urbanized population Among the activities enjoyed by millions of people are boating, sailing, conoeing, water-skiing, swimming, camping, picnicking, and wildlife observation. Most of these activities are water oriented or water enhanced, consequently most outdoor recreational sites are located in close proximity to some type of water body. Hurricane Agnes, with her accompanying heavy rains and flooding, caused many damages which affected the utilization of these facilities throughout the Atlantic states area.

Information concerning the various types of outdoor recreation was gathered from several different sources. State parks commissions from the affected states were able to report estimates of the physical damage to sites in their regions and to estimate the impact on the utilization of these areas. County and village officials were also able to make estimates on the impact of the flooding on the locally operated areas Other information was given by individual campsite area operators.

It was impossible for any of the agencies or people contacted to give final figures on the monetary amount of physical damage sustained by the recreational sites Estimated attendance figures at the sites may not be entirely indicative of the physical damage sustained at any one recreational site It was felt by many of those interviewed that the reduced attendance at most sites was caused by the adverse publicity and continuous reports of heavy damages resulting from the flood

The Pennsylvania State Parks Commission estimated that anticipated attendance was down approximately 10% to 15% state-wide. In the Southern Tier area of New York, attendance at state parks was down approximately 20% from the 1971 period for July and August. Private campsite operators reported up to 50% reductions in attendance during 1972 but the camping activity had returned to near normal in most areas by late August

Many sites in Virginia and Maryland were reported as being closed for one to two week periods following the flood to allow for debris removal and other repairs There was less physical damage reported in these states than in the Pennsylvania and New York areas. West Virginia and Delaware did not report any great physical damages or reduction in attendance.

In general, damages to recreational sites were not serious enough substantially to limit their use for any extended periods of time.

The following are specific examples of damages to recreational sites:

NEW YORK STATE

The Montezuma National Wildlife Refuge sustained damage to approximately 9 miles of roadways and 7 miles of dikes. This damage caused the closing of some areas within the refuge and the loss of waterfowl feed crops such as buckwheat The loss of the concentrated areas of feed available to the waterfowl will probably cause them to find other areas to feed The combination of closed roads and the less concentrated water fowl populations has resulted in 20,000 fewer visitors during 1972 than projected It was expected that the impact of the flood damages will for the most part be of short term duration.

Stony Brook State Park, near Dansville, had portions of the gorge trail closed due to the washing out of some of the foot bridges. The same situation occurred at other gorge parks such as Taughannock and Watkins Glen Most park damages had been repaired, with the exception of Stony Brook, within two to three weeks of Hurricane Agnes and were fully operational

The Allegheny State Park had a reported 75% reduction in attendance over the 4th of July weekend. This was the result mainly of three bridges on access roads from the north having been washed out. Beach areas within the park were closed for a week following the flood

PENNSYLVANIA

The Allegheny National Forest, which is just south of the Allegheny State Park, sustained considerable damage as the result of inundation from water of the Allegheny Reservoir. Most of the recreational facilities of the park are located in the area surrounding Allegheny Reservoir Camping, picnicking and swimming facilities were closed for periods ranging from one week to one month. The last swimming area was opened 34 days after the flood It was estimated that park use was reduced by at least 20% for the year

In Clearfield, Parker Dam State Park was closed all summer due to a bridge washout on the access road to the site. The park itself sustained little damage

The Little Pine State Park, north of Lockhaven was closed all summer due to erosion of roadways and campsites

Other state parks closed all summer include Milton Island, Ravensburg, and Shicklehamy Marina. The Shicklehamy Marina was a new park and had been dedicated on June 18th. It was closed on June 22nd

The Francis Slocum State Park near Kingston has been closed for recreational use. It has been utilized as an emergency housing area by HUD since it is close to the hard hit area of Kingston and Wilkes-Barre and has sewage and water hookups for trailers

Many of the privately owned and operated campsites in the state also received damages from the flood Among those contacted were Bald Eagle Campsite, Brandywine Meadows Family Campground, and Franks' Folly Campsite The operators of these sites reported that damages included roadway and campsite washouts, siltation, and debris For the 1972 season it was estimated that there was a 50% reduction in attendance even though most sites were repaired and fully operational by mid July

MARYLAND

The C & O Canal Park complex which runs from Georgetown to Cumberland incorporates bike and hiking trails, picnic and campsite areas, as well as boating and other water sports in one large park It was reported that nearly the entire length of the canal sustained heavy damage from erosion or siltation (See the Maryland section in Historical Monuments) Drinking water supplies were also contaminated along the canal It was estimated that damages to the park may total $5,000,000 Portions of the park were opened within a week of the floods while other areas will take up to a year to repair.

The Patapsco State Park sustained damages to parking lots, playfields, park roads, bridges and dams as well as to manmade lakes The estimated losses total over $6,000,000 It was estimated that perhaps 30% of the park facilities were damaged to the extent that they will not be reopened for recreational use.

Among the other recreational sites which received damages, mainly to water oriented activities and campsite areas, are Deer Creek Park, Fort Frederick Park, Great Falls Park, Greenbriar State Park, Gambrill State Park and Rock Creek Park.

VIRGINIA

The George Washington National Forest sustained damages to roadways and hiking trails within the park Other recreational areas such as campsites and picnic areas also were damaged Estimated damages totaled approximately $600,000 There was a considerable reduction in park attendance following the flood but impact of the damages was believed to be of short term duration

The Jefferson National Forest sustained damages to access roads, campsites and hiking trails Estimated damages at the park were nearly $500,000 Attendance at the park was reduced approximately 50% Damages were reported as having short term impact.

Lake Fairfax Park in Fairfax County received damage to the spillway and dam. An access road to one portion of the park was washed out and the swimming pool at the park was silted in There was also 2 to 3 feet of silt and other debris left in the picnic area. Partial use of the park was restored within a few weeks. Other damages such as repair of the dam will undoubtedly take a longer period of time.

Bull Run Regional Park received damages to hiking trails, swimming areas, campsites, picnic areas and play areas. It was reported that water in the park was as much as 35 feet deep in some areas The clean up of debris and silt kept the park closed for approximately 3 weeks Attendance at the park was expected to return to normal

Other areas where recreational sites were affected by Hurricane Agnes include: Roanoke, Danville, Appomattox, Covington, Rustburg and Clarksville Damages included erosion and siltation of campsites, picnic areas, hiking trails and playfields. (See photos, Historical Section) Also damaged were fishing piers, boat landings and golf course fairways These damages were generally not serious and would have only short term impact on the utilization of the areas while repairs and restoration were being completed

DELAWARE

There were no reports of damages to recreational sites in Delaware. It would seem safe to assume, however, that attendance at many parks and campsites was reduced due to the publicity of damages sustained in the area.

WEST VIRGINIA

There were little reported damages to recreational sites in West Virginia. The only mention of damages was from Berkley County where it was reported that utilization of the recreational facilities was affected to a minor extent. Other areas in the state may well have also experienced lower attendance due to the publicity of flood damages.

HISTORICAL MONUMENTS

GENERAL

Hurricane Agnes led to very substantial damage and loss with respect to historical artifacts and architecturally significant structures. As expected, the severest losses occurred in areas that were located in the direct path of the Hurricane and its resulting high flood waters (See Figure 1)

The types of historical damage sustained as a result of Agnes ranged from ancient glassware to historically valuable bridges and included such items as books, manuscripts, Indian arrowhead collections, library reference materials, microfilm, geneology data and records, newspapers, gun collections, 18th and 19th century tools and machinery, automobile and transportation museums, covered bridges, and structures representing architecture from the past.

Synopsized below is a partial list of the historical losses and damages suffered as a result of Hurricane Agnes.

VIRGINIA

Old bridges that had been washed out and/or destroyed account for much of the historical damage in Virginia. Included among them are the Old Rock Arch Bridge, a toll bridge near Leesburg, (See photo, this section), and an iron truss bridge which spanned the Occoquan River on Route 123 in Fairfax County The latter had been recognized by many as the last surviving example of a bridge structured from iron trusses. Another destroyed bridge was the Cartersville Bridge which spanned the James River in Goochland County (See photo, this section) It was regarded as a major landmark and is listed in the State Register of Landmarks

Several old mills, one of which was still operating, were either washed away or damaged to such an extent that repair is questionable.

A transportation museum in Roanoke suffered minor damages, mostly due to silt deposition within the museum

In Richmond, Virginia, Belle Island suffered some damage to several buildings and accesses to the island Belle Island served as a prison camp where Union soldiers were retained during the Civil War. There still remains on the island a nail factory of the 1800's and an abandoned Virginia Electric Power Company electrical generating plant.

MARYLAND

The C & O Canal linking the Ohio River and Chesapeake Bay was severely damaged by the Hurricane. National Park Service officials label it a "major disaster" and estimate it will take at least a year and more than $30 million to restore it to "historic integrity" In at least 26 places gaping holes were torn in the canal embankment and sometimes through 300 feet of reinforced earthen walls. Nearly all the water found in the canal lies in tiny pools along the canal bed. The canal towpath is now impassable to hikers and bicyclists for 70 miles of its length due to bank erosion, severe gouging, and over 200,000 uprooted trees in the canal parklands Many of the canal locks have been destroyed and their rocks and pilings carried downstream for hundreds of yards by the floodwaters At lock 7 a new cannel was cut around the lockkeeper's house, and as the floodwaters receded the house was left sitting atop a little rocky promontory. At least 86 stone culverts which carry streams and local runoff beneath the canal, suffered some damage and more than a dozen are considered near collapse Debris, ranging from splintered foot and auto bridges to tents, tables, tires, bottles, clothing, furniture and doors and windows from washed out vacation cottages in Williamsport litter the canal.

WEST VIRGINIA

The Harper's Ferry National Historic Park, while not experiencing the flood of record, sustained water damage to original and reconstructed historical buildings Mud and silt was deposited throughout much of the park

PENNSYLVANIA

The Pennsylvania Historical and Museum Commission in Harrisburg reported that of the more than one hundred historical societies and museums under its organization in Pennsylvania, only four suffered more than minor damage. These four are located in Lockhaven, Wilkes-Barre, Muncy, and Wyoming. These four areas were in the direct path of the Hurricane and actually were hit twice by Agnes as it circled in the east-central portion of the state before passing into New York State (see Figure 1) A total of $100,000 damage was estimated to be done to these four areas in the way of structural loss alone

In Wilkes-Barre and Lockhaven inundation of the ground floors of the buildings caused thousands of books to be destroyed along with legal and historical documents. In Wilkes-Barre, the Wyoming Historical and Geological Society lost many abstract wills and cemetery plot records, and the Free Library lost 85,000 books Both Wilkes College and Kings College lost a significant amount of reference material. The Public Library in Lockhaven suffered $250,000 in damages from loss of books and old archives Also in Lockhaven, several buildings constructed in the early 1800's suffered sever damages as a result of flood waters rising to 6 feet on the first floors.

The Columbia County Historical Society in Bloomsburg, reported that the McGee Historical Museum was completely destroyed and would not reopen The McGee Transportation Museum, a commercial museum displaying old trolleys, trains, automobiles, etc., suffered $40,000 alone in damages to their trolley track as well as many antique autos suffering water damage. This museum may also be forced to remain closed.

Near Bloomsburg, two covered bridges were washed out on Roaring Creek and at least one is beyond repair

The Valley Forge Park Office in Valley Forge, Pa reported that the waters of Valley Creek backed up to within 3 feet of George Washington's Headquarters However, no serious damage was evident.

The Historical Society of York County, Pennsylvania reported that the last covered bridge in York County had been washed away and that a church in Glen Rock had been completely destroyed An Indian Burial Ground at Sheshequin, Pa , was uncovered and 30 skeletons dating back to early 1700 were found

A serious loss of an historical value occurred at the Forty-Fort Cemetery in Forty-Fort, Pa Over 2,500 caskets and nearly as many tombstones were washed out as the Susquehanna River cut into the cemetery grounds. As of September 16, 1972 only 1,200 bodies have been recovered and merely 28 of those identified In Towanda, Pa , the Riverside Cemetery was under water for several days but no serious damage was evident.

NEW YORK

In the State of New York, the worst historical damage by far occurred at the Corning Museum of Glass and its library in Corning, New York. Of the more than 13,000 museum glassware pieces, approximately 400 pieces were damaged or destroyed Of the total of 63,000 photographs, negatives, slides, and prints, 39,000 were completely lost and the 24,000 others may be beyond restoration Many of these photographs would be very difficult to replace since most of the items pictured are in private collections at many locations around the world. Six hundred rare manuscripts (one dating back to 1154) were damaged or destroyed Over 50% of the library's books suffered water damage. Again the important and most serious loss was not the economic loss but the historical loss.

The Corning-Painted Post Historical Society in Corning, New York, was also seriously damaged. Tools, grinding wheels, belts, and wooden parts were lost or damaged Lost also were 1,400 old photographic negatives of glass plates.

Other historical institutions damaged during the flood included the Chemung County Historical Society and the Town of Erwin Historical Society At the Chemung County Historical Society in Elmira, 12,000 items such as letters, maps, and pictures were inundated and possibly damaged beyond restoration Newspaper exhibits dating as far back as 100 years were a total loss A School Loan Exhibit consisting of plastic cases containing various artifacts and other material from the Civil War and Revolutionary War periods, was damaged beyond repair at a loss of $24,000. The Town of Erwin Historical Society also lost such items as women's dresses dating back to the 1870's, 18th and 19th century farm tools, a dog treadle machine, and two Edison phonographs

The Steele Memorial Library in Elmira, New York, suffered much damage to local publications and historical volumes of which an estimated 99% were destroyed Nine thousand reels of microfilm were also damaged Branch libraries of the Steele Memorial Library in Big Flats, Southside, and 222 William Street, Elmira, were nearly completely destroyed.

ROANOKE RIVER - ROANOKE, VA.
RECREATION PARK - INUNDATED

COVINGTON, VA.
PLAY AREA - INUNDATED

LEESBURG, VA.
OLD TOLL BRIDGE

JAMES RIVER
CARTERSVILLE BRIDGE

ECONOMIC IMPACT

Economic impact as it is related to ecological impact is very difficult to define as each individual has his own opinion as to what amount of damage, in dollars, was done to the environment Therefore, this section pertains exclusively to the evaluation of the loss of revenues in such areas as wildlife (Hunting), fishlife (fishing) recreation (vacationing and camping) and historical (visitors and loss or damate to artificts and monuments)

WILDLIFE

Revenue losses related to hunting are expected to be minimal since most of the hunting of large game is done outside the flood plain and these areas were not severely affected Licenses as well as sale of hunting equipment are expected to be unaffected as a result of the flood

FISHLIFE

Fishing revenues, on the other hand, are anticipated to drop over the next few years Due to displacement of fish from upstream to downstream areas and the loss of fishing facilities along the banks of streams such as fishing docks, boat ramps and even shade areas where many species tend to feed, the less avid fishermen may become disenchanted with the sport and not return to particular areas during the same season or the following season This would probably not reduce fishing license revenues next season, but will most definitely mean loss of revenue to certain areas and businesses concerned with promoting sport fishing and selling fishing equipment

The dollar figures for revenue losses suffered by the sport fishing industry this past fishing season as a result of the Hurricane can only be speculative A crude estimate of these losses was attempted, however, based on statistics for sub-regions C,D,E, and F obtained from the North Atlantic Water Resources Study, May 1972, Table O-24. The number of fishermen prior to "Agnes" was extrapolated from the table to be 2,230,000 with a total number of dollars expended by these fishermen to be $198,045,000 This figure for expenditures includes all expenses incurred by fishermen including food, lodging, transportation, etc, as well as actual fishing equipment and licences The estimated range of revenue loss is expected to vary between 15 and 40% Using these values, the revenue loss for the entire study area is expected to be in the range from $19,804,000 and $79,216,000 for the sport fishing industry

The long range effect may be difficult to project as it depends a great deal upon how well stream improvement programs are carried out in relation to restoring fishlife and its related habitat.

RECREATION

Revenue losses related to recreational activities are even more difficult to project It has been reported that the use of park lands and camping areas has diminished by as much as sixty per cent in some areas that escaped total destruction It may be that vacationers, having used the facilities within the flooded areas before, will find or have found vacationing spots in other areas This would be classified as a short term revenue loss. However, it may be that many vacationers will continue to use the new-found areas and avoid the flooded areas even after restoration projects have been completed To the flooded area, this effect would be long term

If the aforementioned migration of vacationers takes place, it could also overburden vacation spots outside the flooded areas that may not have anticipated major increases in tourist population

It is reported that attendance at state parks was down approximately 20% for the 1972 summer season in the states effected by Hurricane Agnes. It is estimated that revenue losses at the state parks may total nearly $13,000,000 for 1972 Losses to private campsite owners are also quite high for 1972 with several areas reporting up to 50% loss of revenue

Many areas, both state and private, have reported that attendance during late August was returning to normal levels This would indicate that the revenue losses experienced may not be long term unless those vacationers that went elsewhere during June and July will not return in the same numbers in the future.

HISTORICAL

With respect to historical monuments the short term revenue losses from museum visitors are considered minimal when placed in comparison with the loss of objects of historical significance However, many museums will have to depend upon visitor revenues to reestablish the buildings and exhibits to preflood conditions Conversely, buildings and exhibits must be restored before visitor revenues can be expected to reach preflood receipts Thus, it is seen that curators of museums or other historically significant structures find themselves in a dilemma which can only be reversed over a long period of time

SUMMARY

Between June 21 and June 24, 1972, the States of Virginia, West Virginia, Maryland, Pennsylvania and New York were hit by a storm coming from the west and hurricane Agnes proceding out of the south resulting in one of the worst rain storms in modern history The storm caused extensive property damage estimated at this time to be approximately four billion dollars In addition to the property damage, a great deal of destruction occurred to the environment including loss of crops and corresponding farm land due to erosion and sedimentation, tree losses along flood plain areas, disruption of fishlife and wildlife, contamination of surface and ground water supplies, destruction to recreational areas and a corresponding loss of visitors to these areas, and permanent and long term damages to historical monuments and artifacts.

Geological characteristics played a major role in determining the types of stream deposits that were identified in each river basin. For instance, sediment deposits of mostly sand and gravel were found in the northern Susquehanna valley due to the unstratified glacial till that characterizes this area. However, deposits in the southern areas which are underlain by igneous and metamorphic formations were mostly of larger stones and gravelly material Large deposits of silt are attributable to the erosion of loess deposits geologically formed by the deposition of fine silt from winds blowing off glacial ice.

Much topsoil was scoured from agricultural lands and deposited either directly in the stream beds or on other lands downstream. Pennsylvania reported the largest loss of agricultural land due to erosion and gouging - an estimated 819,525 acres Not only did the erosion of crop lands contribute large quantities of sediment to streams but it also introduced materials such as nitrogen, pesticides, herbicides and chlorinated hydrocarbons

Tree damage and losses were minimal when compared with other ecological destruction Most of the trees damaged were found in the various flood plains and were victims of high velocities, soil erosion and subsequent exposure of root systems, high dissolved solids content of flood waters and extended periods of inundation. Commercial value of these damaged trees was considered insignificant when compared to the decrease in bank stability they represent.

The rainy period prior to the flood had as much, if not more, of an adverse effect on the smaller and young wildlife and bird life than the actual high waters did. Larger animals were able to migrate to higher ground For the most part, only those that were trapped on island or near the banks of flooded streams were drowned.

Fishlife was affected far more adversely than wildlife Fingerlings were washed downstream into bay areas and many of the adult fish were displaced to downstream locations Fish habitat was severely altered by siltation or bottom scouring which depleted much of the stream plant life, thus upsetting the food chain The impact of the flood on water quality may be considered both beneficial and adverse in that, whereas, the flooding resulted in the flushing of many contaminants present in the stream prior to the storm, much silt and nutrient material took up residence in the bottom muds of the streams during and after the flood The net result, however, is not presently evident owing to a lack of

data collected during the flooding. Intermediate and long term effects on the water quality can only be evaluated by an extended monitoring program and comparing the data with previous water quality data. Owing to the disregard of flood waters for state boundaries, it became evident during the study that a coordinated interstate surveillance network is needed such as the Federal "STORET" system.

Recreational facilities that were located in the flood plain were damaged severely. Siltation of park lands appears to be a major factor in a number of areas forcing the closing of these areas and consequent loss of revenues. In some cases major facilities were damaged and may require one to two years for repair. If vacationers seek and find other vacation spots, it is possible that these areas may require a period of a few years for former attendance levels to be restored.

Historical damages included losses of exhibits, bridges, antique tools, machinery and museum pieces as well as books and magazines. In many cases these items are irreplaceable. Aside from moving museums out of the flood plains, precaution should be taken to store materials susceptible to water damage on the upper floor of a museum as opposed to the basement. In the case of Agnes this would have prevented much of the damage to such articles.

TABLE 4

DEGREE OF FLOOD IMPACT ON ECOLOGICAL FACTORS

Section	Ecological Factor	Duration of Impact		
		Short-term	Intermediate	Long-term
Soil Erosion & Sedimentation	Agricultural Topsoil Loss			X
	Nutrient Leaching		X	
	Microbial Disruption	X		
	Siltation			X
Tree Damage	Stream Bank Stabilization			X
	Wildlife Shelter	X		
Wildlife	Species Displacement		X	
	Food Loss	X		
	Vegetation Shelter Loss	X		
Fishlife	Food Loss		X	
	Stream Environment Altered			X
	Fingerlings		X	
	Adult Fish	X		
Water Quality	Mine Waters	X		
	High Turbidity	X		
	Oil Spills-Benthic Demand			X
	Culm Piles	X		
	Agricultural Sources - Nutrients	X		
	Agricultural Sources - Chlorinated Hydrocarbons			X
	Sewage	X		
Recreation	Physical Damage - Siltation		X	
	Loss of Facilities		X	
	Revenue Loss - Vacationers		X	
Historical	Loss or Damage to Monuments or Artifacts			X*
	Revenue Loss - Visitors		X	

* In many cases irreplaceable

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- U.S.D.A. - Soil Conservation Service
- N.Y.S. Department of Environmental Conservation
- N.Y.S. Bureau of Solid Waste Disposal
- Pennsylvania Department of Environmental Resources
- Pennsylvania State Fish Commission
- Maryland Bureau of Engineering
- Maryland Wildlife Administration
- Maryland State Roads Commission
- Virginia Department of Parks and Recreation
- Virginia Department of Fish and Game

- Virginia Bureau of Sanitary Engineering

- West Virginia Resources Conservation and Development Commission

A more extensive list including county and municipal officials and members of independent organizations within the study area appears in Appendix A.

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APPENDIX A

LISTING OF PERSONAL INTERVIEWS AND CONTACTS

RECON STUDY OF ECOLOGICAL IMPACT
OF HURRICANE AGNES 1972

NEW YORK

Location	Area Tributary To	Association	Major Comments
Chemung Co Steuben Co.	Chemung & Cohocton Rivers	NYS Bureau of Solid Waste Disposal	Problems arising from large amounts of solid waste disposal
Steuben Co. Chemung Co.	Chemung & Cohocton Rivers	Dept. of Health	Shortage of food and water supplies in flood counties
Bath, Steuben Co	Cohocton River	District Conservationist *Soil Conservation Service*	Soil erosion, crop damage
Elmira, Chemung Co.	Chemung River	ASCS Extention Co-op	Damage to land, livestock, crops and others
Allegheny St. Pk., Cattaraugus Co	Allegheny River	Park Commissioner	Recreational impact
New York State	Allegheny & Genesee Rivers	NYSDEC - Wildlife Management Director	Stream damage and wildlife damage
Allegheny St. Pk., Cattaraugus Co	Allegheny River	U.S. Forest Service Supervisor's Office	Flood damage report - Allegheny National Forest
Corning glass Works Steuben Co.	Chemung River	Corning Museum	Loss of artifacts in Corning Museum of Glass
Bath, Steuben Co.	Cohocton River	Foresters & NYSDEC	Timber loss, vegetation loss
Taughannock St. Pk., Schuyler Co.	*Chemung River*	NYSDEC	Recreational impact and cleaning of debris and loss of attendance in parks
Elmira, Chemung Co.	Chemung River	Chemung Co. Historical Society	Historical items destroyed
Painted Post, Steuben Co	Chemung River	Town of Erwin Museum	Historical items destroyed
Corning, Steuben Co	Chemung River	Corning-Painted Post Historical Society	Historical items destroyed
Elmira, Chemung Co.	Chemung River	Steele Memorial Library	Historical items destroyed in flood
Chemung Co.	Chemung River	Soil Conservation Service	Comments on stream damage and stream rehabilitation
Bath, Steuben Co.	*Cohocton River*	Pesticide Inspectors NYSDEC	Loss of strong pesticides and large amounts of mosquitoes in flood plain
Middletown, Orange Co.	Hudson River	Dist. Conservationist USDA-SCS	Soil erosion and loss of farmland
New Platz, Ulster Co	Hudson River	NYSDEC - Regional Office	Temporary displacement of waterfowl, fishing and wildlife.

NEW YORK (Cont'd.)

Location	Area Tributary To	Association	Major Comments
Avon, Livingston Co.	Genesee River	NYSDEC	Some timber loss
Avon, Livingston Co.	Genesee River	NYSDEC	Stream and fishing damage
Portageville Wyoming Co.	Genesee River	Historian	Historical damage
Belmont, Allegheny Co.	Genesee River	USDA - Soil Cons.	Stream, timber, animal and historical damage
Montezuma Refuge Seneca Co.	Genesee River	Refuge Manager	Timber loss, animal kill and farmland damaged
Belmont, Allegheny Co.	Genesee River	Agricultural Extension Service	Wildlife habitat damaged, timber loss, animal kill and stream damage
Avon, Livingston Co.	Genesee River	Regional Director NYSDEC	Stream, forest, and fish damage
New York State		NYSDEC	Damage to nursery in Painted Post
New York State		NYSDEC	Stream debris
Horseheads, Chemung Co.		Army Corps	Supply us with detailed maps of debris on several rivers
Albany		NYSDEC-Environmental Management	Stream damage

RECON STUDY OF ECOLOGICAL IMPACT
OF HURRICANE AGNES 1972

PENNSYLVANIA

Location	Area Tributary To	Association	Major Comments
State of Pennsylvania		Penn State Fish Commission	Fish Commission proposal on how COE should handle stream rehabilitation projects
Bradford Co Sullivan Co	Susquehanna River	Dist. Conservationist SCS	Damaged crop land, tabulations of losses in Bradford Co
Lackawanna Co.	Susquehanna River	Dist. Conservationist SCS	Crop damage, sheet erosion damage appraisal
Luzerne Co.	Susquehanna River	Dist Conservationist SCS	Land damage, crop loss
Wyoming Co.	Susquehanna River	Dist Conservationist SCS	Land damage, crop damage
Lackawanna Co.	Susquehanna River	Pa. Dept of Environmental Resources	Timber loss
Bradford Co. Sullivan Co.		Pa. Dept. of Public Health	Partial accounting of well analysis
State of Pennsylvania	Tioga River	USDA-SCS	Damage done in Tioga County
State of Pennsylvania		Bureau of Forestry	Tree damage
State of Pennsylvania	Susquehanna River	Ass't. Regional Supervisor Pa. Fish Commission	Stream damage
State of Pennsylvania	Northeast Pa.	USDA-SCS	Stream crop and timer damage
Harrisburg	Lower Susquehanna River	DER-Game Commission	Wildlife and animal damage
Harrisburg		Bureau of Water Quality Management	Number of treatment plants and water treatment plants out of service
Dallas	Susquehanna River	Pa. Game Commission	Animal loss
Pottstown, Montgomery Co.	Schuylkill River	Field Disaster Office - EPA	Oil spillage from flood
W. Reading, Montgomery Co.	Schuylkill River	Pa. Dept of Health	STP information in eight of the southwestern counties in Pa
Kingston, Luzerne Co	Susquehanna River	Pa. Dept. of Health Chief of Operations	WTP & STP information of northeastern counties
Kingston, Luzerne Co.	Susquehanna River	Bureau of Community Environmental Control	Information on individual water supplies

PENNSYLVANIA (Cont'd.)

Location	Area Tributary To	Association	Major Comments
Kingston, Luzerne Co.	Susquehanna River	Pa. Dept. of Health	Listing of flood debris sites.
Jersey Shore Lycoming Co.	Susquehanna River	Pa. Game Comm.	Wildlife lost
Sunbury, Northumberland Co.	Susquehanna River	USDA-SCS	Stream erosion and sedimention, crop loss and scouring
Williamsport Lycoming Co.	Susquehanna River	USDA-SCS	Need for total stream rehabilitation and summary of losses in Lycoming Co.
Harrisburg		Pa. Dept. of Environmental Resources	Course change in stream.

RECON STUDY OF ECOLOGICAL IMPACT OF HURRICANE AGNES 1972

MARYLAND

Location	Area Tributary To	Association	Major Comments
Union Bridge, Carroll Co	Patapsco River	Mayor	Sewage system adequate - some flooding of lagoon
Cambridge, Dorchester Co.	Chesapeake Bay	Mayor	Some trees uprooted
Easton, Talbot Co.	Chesapeake Bay	Board of County Commissioners	Sewage system adequate
Mt. Rainier, Prince Georges Co.	Potomac River	Mayor	Some soil erosion and changes in flood plain
Bladensburg, Prince Georges Co.	Potomac River	Mayor	Sewage system adequate
Vienna, Dorchester Co.	Chesapeake Bay	Mayor	Sewage system adequate
Greenbelt, Prince Georges Co.	Potomac River	Mayor	Sewage system adequate
Taneytown, Carroll Co.	Patapsco River	Mayor	Pumps flooded in sanitary sewers
Salisbury, Wicomico Co.	Chesapeake Bay		Sewage system adequate
Taneytown, Carroll Co.	Patapsco River		No damage
Westminister, Carroll Co.	Patapsco River	Carroll County Sanitary Commission	Some effect on water supply
Hurlock, Dorchester Co	Chesapeake Bay	Mayor	No damage
Easton, Talbot Co.	Chesapeake Bay	Mayor	No damage
Patapsco St. Pk.	Patapsco River	Park Ranger	Stream debris
Deer Creek Pk., Anne Arundel Co.	Chesapeake Bay	Administrator - Park Commission	Recreational impact
Patapsco St. Pk.	Chesapeake Bay	Administrator - Park Commission	Stream damage and recreational impact
Gunpowder Falls Pk.	Potomac river	Administrator - Park Commission	Stream damage
State Parks, Frederick & Washington Co	Potomac River	Area Supervisor	Regional impact
C & O Canal Pk.	Potomac River	USSC - Asst. to Operation Div. Eng.	Recreational impact
Glen Burnie	Chesapeake Bay	Administrative Division-Dept of Public Works	Damage to treatment facilities

MARYLAND (Cont'd.)

Location	Area Tributary To	Association	Major Comments
Silver Springs, Montgomery Co.	Potomac River	*Md. Capital Pk. and Planning*	*Wildlife damage, stream* damage
Towson, Baltimore Co.	Patapsco River	Baltimore Dept. of Health	Stream erosion and sedimentation
Cambridge, Dorchester Co.	Chesapeake Bay	Engineer	Wildlife damage and sedimentation
Ellicott City, Howard Co	Patapsco River	Bureau of Engineering	Wildlife damage, stream and timber damage, historical artifacts lost, recreation hindered
Hancock, Washington Co.	Potomac River	Mayor	Stream and recreational damage
Annapolis, Anne Arundel Co.	Chesapeake Bay	Bureau of Road Operations	Stream sedimentation and infiltration to sanitary sewers
Bel Air, Hartford Co.	Susquehanna Flats	Director of Administration	Stream erosion and wildlife lost
Centreville, Queen Annes Co.	Chesapeake Bay	Mayor	Wildlife damage and stream erosion
Annapolis, Anne Arundel Co.	Susquehanna Flats	Wildlife Adm.	Wildlife damage and animal kill
Carroll Co	Patapsco River	Carroll Co. Sanitary Commission	Inundated treatment plants
Gaithersburg, Montgomer Co.	Potomac River	Mayor	Wildlife damage and soil erosion
College Park, Prince George Co.	Potomac River	City Administrator	Soil erosion
Frederick, Frederick Co.	Potomac River	City Engineer	Stream erosion and treatment plant flooding
	Patapsco River	OEP	Stream debris
Hagerstown, Washington Co.	Potomac River	Wash. Co. Sanitary Comm.	Stream debris and recreational impact
Frederick Co.	Potomac River	Fred. Co. Metro. Comm.	Treatment plant inundated
Montgomery Co.	Patuxent River Chesapeake Bay	WSSC - Asst. to Operations	Stream debris treatment plant inundated and recreational impact
Baltimore, Baltimore Co.	Patapsco River Chesapeake Bay	Asst. Commissioner of Health	Wildlife refuge inundated, stream erosion, drinking water contaminated
Baltimore, Baltimore Co.	Patapsco River Chesapeake Bay	Div. of Wastewater	Treatment Plant

MARYLAND (Cont'd.)

Location	Area Tributary To	Association	Major Comments
Baltimore Baltimore Co.	Patapsco River Chesapeake Bay	Water Division	Treatment of drinking water
Towson, Baltimore Co	Patapsco River	Dept. of Public Works	Repair of sewer lines
Annapolis, Anne Arundel Co.	Severn River Chesapeake Bay	City Engineer	90% clam beds destroyed 30% oyster beds destroyed Recreation restricted
Baltimore Baltimore Co.	Patapsco River Chesapeake Bay	Maryland State Roads Commission	Increased erosion - raw water more turbid
Berwyn Heights, Prince Georges Co.	Anacostra River James River	Chairman	Permanent damage to forested areas, some erosion, recreation facilities limited
Betterton		President of Commissioners	Damage to forested areas sediment and erosion
Capital Heights, Prince Georges Co.	Anacostra River Potomac River	Mayor	Erosion, raw water quality effected, rerouting of streams influence on recreation
Chery Chase Montgomery Co.	Rock Creek Potomac River	Chairman	Some trees lost and some erosion, some sewers flooded
Crisfield, Somerset Co.	Chesapeake Bay	Mayor	No problems
Cumberland Allegany Co.	North Branch Potomac River	Allegany Co. Commissioners	Small streams washed out adjoining ground areas
Greensboro		Mayor	No problems
Hagerstown, Washington Co	Potomac River	Supt Water Treatment	Refuge areas inundated raw water quality changed 2 weeks after storm - algal recreational areas closed along C & O Canal
Hagerstown, Washington Co		Wash. County Sanitary Commission	Refuge areas inundated, some erosion, sewerage facilities subjected to high infiltration
College Park, Prince Georges Co		U.S. Dept. of Agriculture - Soil Conservation Service	Damage principally confined to area east of Catoctin Mts in Frederick County and west of Charles, Prince Frederick and Kent
Cumberland, Allegany Co.	North Branch Potomac River	Mayor	C & O Canal aqueduct severely affected

MARYLAND (Cont'd.)

Location	Area Tributary To	Association	Major Comments
Frederick, Frederick Co		President - Board of County Commissioners	Some erosion, raw water quality affected, final water quality affected some recreation areas
Bowie, Prince George Co.	Patapsco River Chesapeake Bay	Mayor	Sewage treatment
Easton, Talbot Co.	Chesapeake Bay	County Engineer	Shore erosion
Kennedyville, Kent Co.	Chesapeake Bay	Kennedyville Water Ass.	Stream erosion
Brunswick, Frederick Co.	Potomac River	Mayor	Stream erosion, water supply and sewer damage
Hyattsville, Prince George Co.	Potomac River	Mayor	Stream erosion and some inundated wildlife refuge
Rockville, Montgomery Co.	Patapsco River	County Executive	Animal loss
Boonsboro, Caroline Co.	Chesapeake Bay	Mayor	Stream erosion and sedimentation
Secretary, Dorchester Co.	Chesapeake Bay	Mayor	Stream erosion and sedimentation
Westminister, Carroll Co.	Chesapeake Bay	President	Animal kill and soil erosion
Boonsboro Carolina Co.	Chesapeake Bay	Bonnsboro Municipal Utilities Commission	Soil erosion
Frederick, Frederick Co	Chesapeake Bay	General Superintendent	Inundated wildlife refuge, stream sedimentation and erosion
Harve de Grace, Hartford Co.	Susquehanna Flats	Harve de Grace Municipal Utilities Comm.	Stream erosion and recreational impact
Hyattsville, Prince Georges Co.	Potomac River	Public Information Office Washington Suburban Sanitary Commission	Some inundation of wildlife, some timber loss and soil erosion
La Plata, Charles Co.	Potomac River	Engineer Aide	Inundation of wildlife, loss of trees, stream sedimentation and erosion, some sewer lines broken and streams rerouted
Laurel, Prince Georges Co.	Chesapeake Bay	City Supervisor	Timber loss, extreme soil erosion, historical damage and recreational damage
Leonardtown, St. Mary's Co.	Potomac River	President - Commissioners of Leonardtown	No damage

MARYLAND (Cont'd.)

Location	Area Tributary To	Association	Major Comments
Luke, Allegany Co.	Potomac River	Mayor	No damage
Manchester, Carroll Co.	Chesapeake Bay	Mayor	No damage
Ocean City, Worcester Co.	Atlantic Ocean	Mayor	Soil erosion on the beach
Oxford, Talbot Co	Chesapeake Bay	President of Commissioners	No damage
Prince Frederick, Calvert Co.	Chesapeake Bay	Administrative Director County Commissioners	Some sedimentation
Rock Hall, Kent Co	Chesapeake Bay	Town Engineer - Rock Hall Water Board	No damage
Rockville Montgomery Co	Potomac River	Rockville - Dept. of Public Works	Stream sediment and erosion, flood plain changes
Salisbury, Wicomico Co.	Chesapeake Bay	President - County Council	Inundated wildlife refuge
Snow Hill, Worcester Co	Chesapeake Bay	Worcester Co. Sanitary District	No damage
Takuma Park Montgomery, Prince Georges Co.	Potomac River	Mayor	Stream sediment and erosion, some recreational impact
Upper Marlboro Prince Georges Co.	Chesapeake Bay	Mayor	Inundated wildlife, community sewerage facilities inadequate, some recreational impact

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VIRGINIA

Location	Area Tributary To	Association	Major Comments
Pearisburg, Giles Co.	New River	Town Manager	No damage
Elkton, Rockingham Co.	Shenandoah River	Mayor	Some streams flooded
Woodstock, Shenandoah Co.	Shenandoah River	Mayor	No damage
Pocahontas, Tazewell Co.	East River	Mayor	No damage
West Point, New Kent Co.	York River	Mayor	No damage
Smithfield, Isle of Wight Co.	James River	Mayor	Damage to shellfish industry
Floyd, Floyd Co.	New River	Mayor	No damage
Tappahannock, Essex Co.	Rappahannock River	County Commissioners	Oyster beds lost due to fresh water flooding
Warsaw, Richmond Co.	Rappahannock River	Mayor	No damage
Portsmouth, Norfolk Co.	James River	Mayor	No damage
Farmville, Prince Edward Co.	Appomatox River	County Commissioners	Some young birds damaged
Richmond, Va.	James River	Richard Times Dispatch	Newspaper clippings from Richmond Area
Harrisonburg, Rockingham Co.	Shenandoah River	Mayor	No damage
Prince George Co.	James River	County Administrator	No damage
Surry, Surry Co.	James River	County Commissioners	No damage
Claremont, Surry Co.	James River	Mayor	No damage
Hamilton, Loudoun Co.	Potomac River	Mayor	No damage
Ridgeway, Henry Co.	Dan River	Mayor	No damage
Alberta, Brunswick Co.	Meherrin River	Mayor	No damage
Suffolk, Nansemond Co.	James River	County Commissioners	No damage
Radford, Pulaski Co.	New River	Mayor	No damage
Timberville, Rockingham Co.	Shenandoah River	Mayor	No damage

VIRGINIA (Cont'd.)

Location	Area Tributary To	Association	Major Comments
Chesapeake, Norfolk Co.	Chesapeake Bay	Mayor	No damage
Berryville, Clarke Co.	Shenandoah River	Mayor	No damage
Bedford, Bedford Co.	Roanoke River	County Commissioners	No damage
Strasburg, Shenandoah Co.	Shenandoah River	Town Manager	No damage
Annandale, Fairfax Co.	Potomac River	Engineer-Director	No damage
Herndon, Fairfax Co.	Potomac River	Town Manager	No damage
White Stone, Lancaster Co.	Rappahannock River	Mayor	No damage
Hillsville, Carroll Co.	New River	Mayor	No damage
Troutville Botetourt Co.	Roanoke River	Mayor	No damage
Roanoke, Roanoke Co.	Roanoke River	Mayor	Stream erosion and treatment facilities operation
Appomattox, Appomattox Co.	Appomattox River	Mayor	Wildlife destroyed, stream erosion and historical artifacts destroyed
Narrows, Giles Co.	New River	Town Manager	Drinking water contaminated
Salem, Roanoke Co.	Roanoke River		Stream debris and water treatment plant
Covington, Alleghany Co.	New River	Mayor	Wildlife, streams and recreational impact
Clifton Forge, Alleghany Co.	Jackson River		Treatment Plant and streams
Pulaski Co.	New River	Exc. Sec.	Stream damage
Roanoke, Roanoke Co.	Roanoke River	Dept. of Parks & Recreation Engineer	Stream and recreational damage
Danville, Pittsylvania Co.	Dan River	Civil Defense Coor.	Stream debris, waste treatment plant, and recreational impact
Danville, Pittsylvania Co.	Dan River		Erosion damage
Town of Buena Vista Rockbridge Co.	James River	Dir. of Public Works	Stream damage, treatment plant infiltration
Appomattox Nat. Hist. Pk., Appomattox Co.	Appomattox River	Acting Park Sup.	Wildlife damage, recreational impact

VIRGINIA (Cont'd.)

Location	Area Tributary To	Association	Major Comments
Rustburg, Campbell Co.	James River	Farm Agent	Stream erosion
Salem, Roanoke Co.	Roanoke River		Timber, animal loss and stream damage
Buena Vista, Rockbridge Co.	James River	Mayor	Sent clippings from area newspapers
Norfolk, Prince Anne Co.	Chesapeake Bay	City Manager	Loss of some sea vegetation due to fresh water
Alexandria, Fairfax Co.	Potomac River	Director of Public Works	Wildlife damage, timber loss, and sanitation damage
Richmond, Henrico Co.	James River	Chief of Game Chief of Fish	Stream and wildlife damage
Richmond, Henrico Co.	James River	Water Control Board	Treatment plant damage
Stafford, Stafford Co.	Potomac River	Director-Occoquan Sanitary District	Treatment plant damage
Fredericksburg, Spotsylvania Co.	Potomac River	Mayor	Sanitary sewer system
Berryville, Clarke Co.	Shenandoah River Potomac River	Health Dept.	Stream damage
Luray, Page Co.	Shenandoah River	County Commissioners	Wildlife damage, fish kill
Montross, Westmoreland Co.	Potomac River	Clerk	Clippings of flooded area
Arlington, Fairfax Co.	Potomac River	Administrative Aide	Stream damage and wildlife damage
Leesburg, Loudoun Co.	Potomac River	USDA-SCS Dist Conservationist	Stream damage and recreational impact
Front Royal, Warren Co.	Shenandoah River Potomac River	County Clerk	Stream damage and wildlife damage
Washington, District of Columbia	Potomac River	U.S. Forest Service	Stream damage and recreational impact
Jefferson National Forest	Potomac River	U.S. Forest Service	Stream damage and recreational impact
Frederick Co.	Potomac River	Dept. of Planning & Development	Damage to highways, homes and crops
Stafford, Stafford Co.	Potomac River	County Commissioners	Stream sedimentation and erosion
Waynesboro, Augusta Co.	Fork River Shenandoah River	Waynesboro News	Stream erosion
Charlottesville, Albemarle Co.	James River	City Manager	Operation of sewage treatment plant, recreational impact

VIRGINIA (Cont d.)

Location	Area Tributary To	Association	Major Comments
Charlottesville, Albemarle Co.	James River	County Commissioners	Wildlife kill, inadequate sewer system, recreational impact and flood plain debris
Powhatan, Powhatan Co.	James River	County Commissioners	Erosion and wildlife damage
Petersburg, Prince George Co.	James River	Mayor	No damage
Buckingham, Buckingham Co.	James River	County Commissioners	Animal kill and soil erosion
Culpeper, Culpeper Co.	Rappahannock River Chesapeake Bay	Mayor	Flood plain changes
Amherst, Amherst Co.	James River	County Commissioners	Heavily inundated wildlife refuge, soil erosion, stream rerouting and recreational impact
Staunton, Augusta Co.	Fork River Shenandoah River	County Commissioners	Soil erosion, inundated drinking water treatment
Clover, Halifax Co.	Dan River	Mayor	Inundation of wildlife refuge, soil erosion and wildlife loss
Altauista, Campbell Co.	Roanoke River	Mayor	Inundation of wildlife and small animals killed
Boydton, Mecklenburg Co.	Kerr Reservoir	County Commissioners	Stream erosion
Clarksville, Mecklen burg Co.	Roanoke River	Mayor	Inundated wildlife refuge damage to forest land stream erosion
Stuart, Patrick Co.	South River Dan River	County Commissioners	Stream erosion
Pittsylvania Co.	Dan River	County Commissioners	Stream erosion and recreational damage
Rustburg, Campbell Co.	Roanoke River	County Commissioners	No damage
Berryville, Clarke Co.	Shenandoah River	County Commissioners	No damage
Farmville, Prince Edward Co.	James River	Town Manager	Newspaper clippings from flood
Buchanan, Botetourt Co.	James River	Major	Fish kill and stream erosion
Pulaski, Pulaski Co.	New River	Mayor	Stream sediment and erosion
Goshen, Rockbridge Co.	North River James River	Mayor	No damage

VIRGINIA (Cont'd.)

Location	Area Tributary To	Association	Major Comments
Chesterfield, Chesterfield Co.	James River	County Commissioners	Wildlife inundated, STP flooded
Iron Gate, Alleghany Co.	James River	Mayor	Soil erosion and affected recreation
Lynchburg, Amherst Co.	James River	Mayor	Forest damage, stream erosion and minor recreational damage
Roanoke, Roanoke Co.	Roanoke River	Forest Supervisor Jefferson National Forest	Extreme erosion of roads and sedimentation of streams and beach damage
Culpeper, Culpeper Co.	Rappahannock River	County Commissioners	Stream erosion, STP flooded and flood plain changed
Edinburg, Shenandoah Co.	Shenandoah River	Mayor	No damage
Suffolk, Nansemond Co.	James River Chesapeake Bay	Mayor	No damage
Hopewell, Prince George Co.	James River	Mayor	No damage
Leesburg, Loudoun Co.	Potomac River	Mayor	No damage
Front Royal, Warden Co.	Shenandoah River Potomac River	Mayor	Inundation of wildlife
Lovingston, Nelson Co.	James River	County Commissioners	Timber loss, stream sediment, rerouting streams, change in flood plain, damage in recreational areas
Lawrenceville, Brunswick Co.	Buggs Lake	Mayor	
Washington, Rappahannock Co.	Rappahannock River	County Commissioners	No damage
Salem, Roanoke Co.	Roanoke River	County Commissioners	Stream erosion and stream rerouting
Eastville, Northampton Co.	Chesapeake Bay	Mayor	No damage
Belle Haven, Accomack Co.	Chesapeake Bay	Mayor	No damage
Madison, Madison Co.	Rappahannock River	County Commissioners	Stream erosion
Towns Brook, Shenandoah Co.	Fork River to Shenandoah to Potomac River	Mayor	Stream sediment and erosion

VIRGINIA (Cont'd.)

Location	Area Tributary To	Association	Major Comments
Staunton, Augusta Co.	Mattaponi River Chesapeake Bay	Mayor	Stream erosion and marked effect on raw water supply
LaCrosse, Mecklenburg Co.	Dan River	Mayor	No damage
Rich Creek, Giles Co.	New River	Mayor	No damage
Tappahannock, Essex Co.	Rappahannock River	Mayor	No damage
Richmond, Henrico Co.	Entire state	Director-Bureau of Sanitary Engineering	Listing of raw water impounding reservoirs-for cities and counties
Warrenton, Fauquier Co.	Potomac River	Mayor	Some inundated wildlife, stream erosion and some recreational damage
Mount Jackson, Shenandoah Co.	Shenandoah River	Mayor	No damage
Hanover, Hanover Co.	Pamunkey River	County Commissioners	Some stream erosion
Warm Springs, Bath Co.	Olga River to East River	County Commissioners	Some stream erosion
Isle of Wight, Isle of Wight Co	James River	County Commissioners	No damage
Irvington, Lancaster Co.	Rappahannock River	Mayor	Reduction of damaged oyster beds
Woodstock, Shenandoah Co.	Fork River to Shenandoah River	County Commissioners	No damage
Keysville, Charlotte Co.	Roanoke River	Mayor	Stream erosion

RECON STUDY OF ECOLOGICAL IMPACT
OF HURRICANE AGNES 1972

WEST VIRGINIA

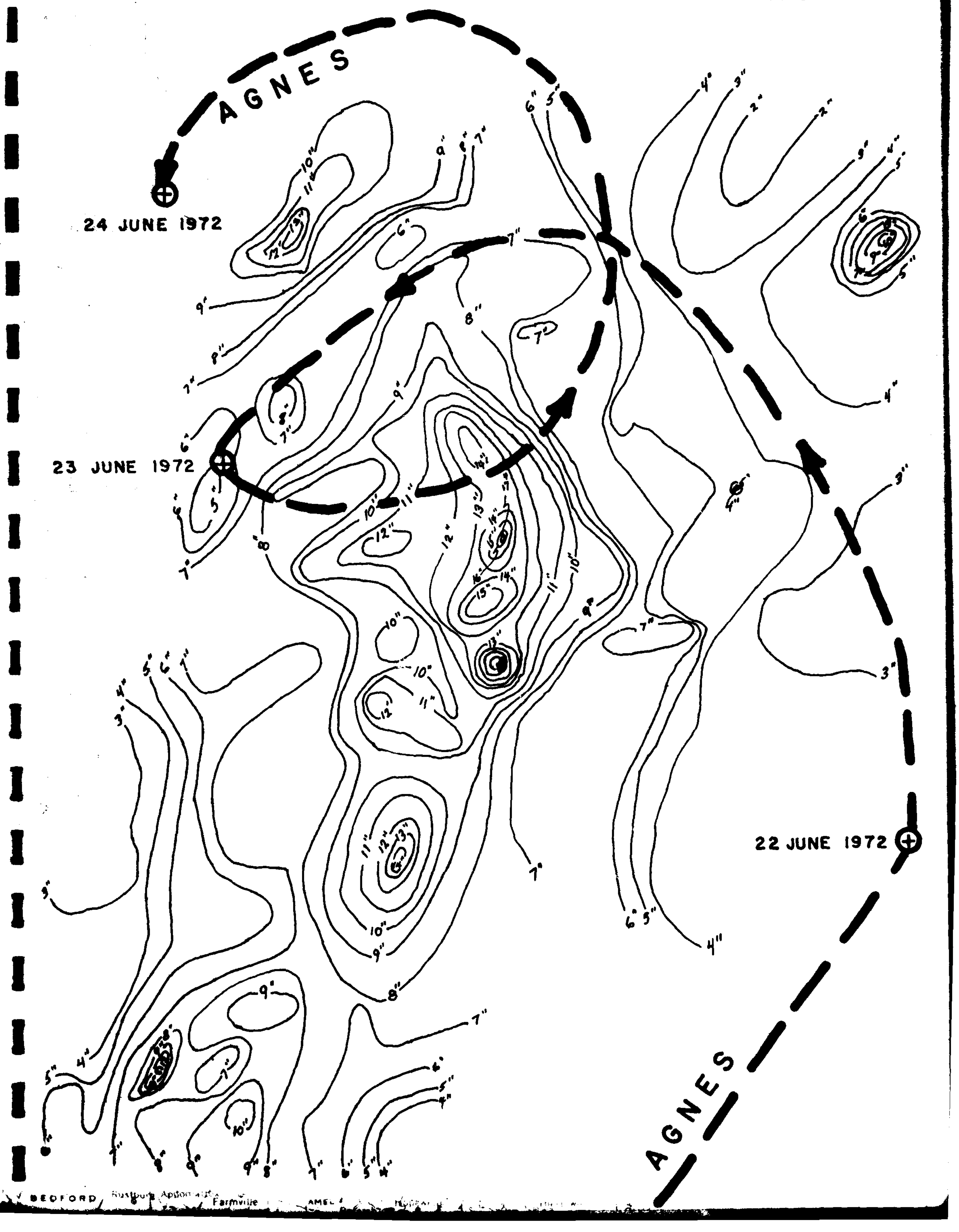
Location	Area Tributary To	Association	*Major Comments*
Madison, Boone Co.	Kanawha River	County Commissioners	No damage
Parkersburg, Wood Co.	Ohio River	President - County	No damage
Romney, Hamshire Co.	Potomac River	County Commissioners	No damage
Kingwood, Preston Co.	Monongahela River	County Commissioners	No damage
Moundsville, Marshall Co.	Ohio River	County Commissioners	No damage
Beckeley Co.	Potomac River	Planning Director	Stream damage
Jefferson Co.	Shenandoah River Potomac River	Resource Conservation and Development Commission	Stream damage
Monongahela Nat. Forest	Monongahela River Ohio River	U.S. Forest Service	Some wildlife lost, debris in stream and loss in recreation
Elkins	Monongahela River Ohio River	Deputy Survey Supervisor - Monongahela National Forest	Loss in some fish scouring and sedimentation in stream

RECON STUDY OF ECOLOGICAL IMPACT
OF HURRICANE AGNES 1972

MISCELLANEOUS

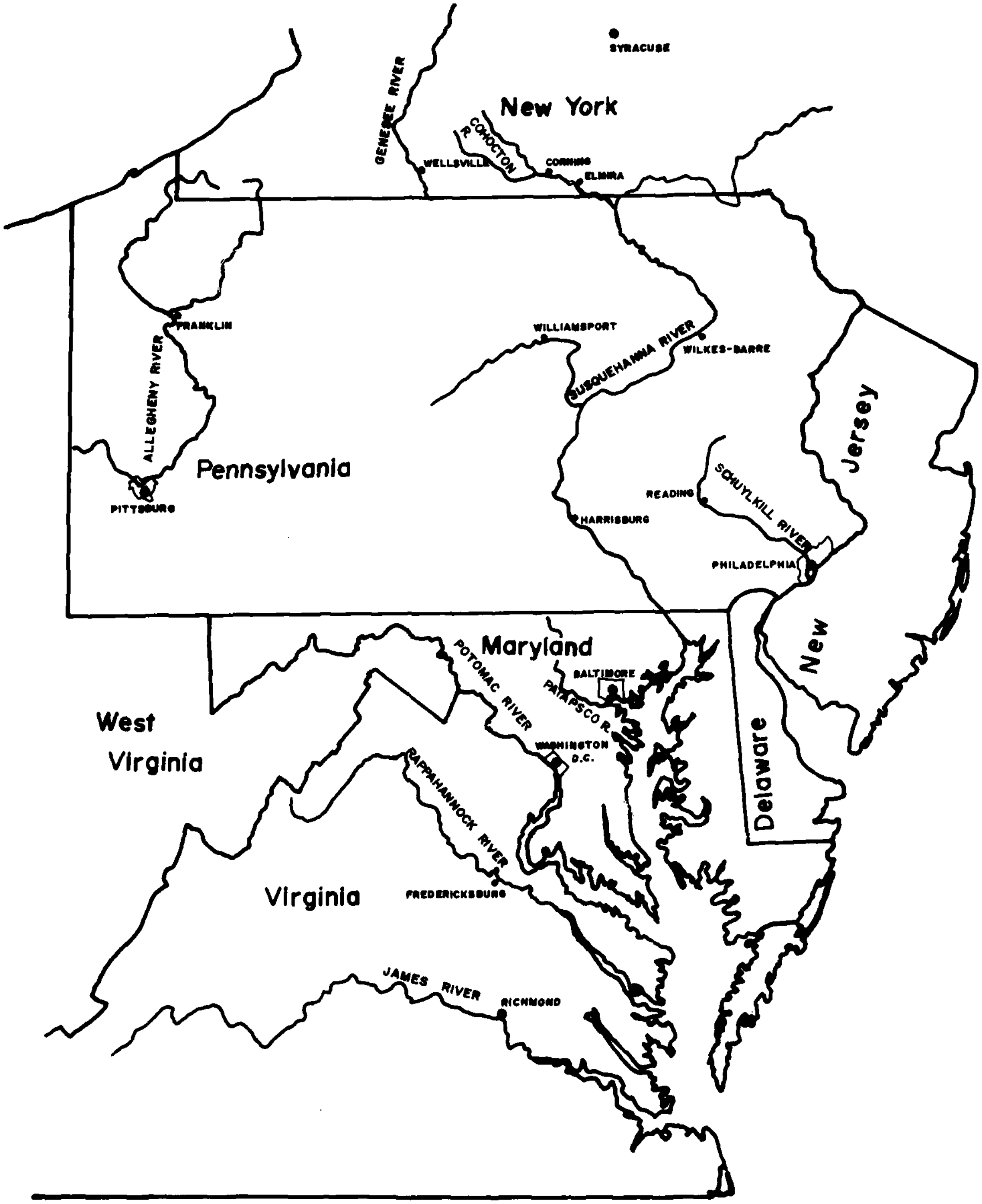
Location	Area Tributary To	Association	Major Comments
U.S. Dept. of Interior Fish and Wildlife Service-Boston, Mass.		Regional Director	General statement about Hurricane for whole eastern seaboard
U.S. Dept of Interior Fish and Wildlife Service-Washington D.C.		Director	Silt deposits repair of storm damages
U.S.D.A. - Syracuse		State Executive Director	Estimate of disaster damage in N.Y.S.
		N.Y.S. Dept. of Environmental Conservation	Gave us other references
		Dept. of Agronomy Cornell	Vegetation problem, silt problem
		N.Y.S. Soil & Wildlife Conservation Comm.	Prevention of future flood damage
		Dept. of Agriculture Economics	Problems for Agric. and recommendations
		Water Quality Surveillance	Will send water parameter for many river basins
		NYSDEC - Direct of Fish and Game	Vegetation damage and fish damage
		Fisheries	Loss of fish, problems in regaining fish population, recommendation for improvement
		SUNY-School of Forestry S.U.	Leaching of the topsoil, loss of nutrients, recommendations for future rehabilitation
		Asst. Professor Dept. of Agronomy	Effects of oil spill on crop growth
		Va. St. Parks	Very minor damage to parks
		Agricultural Program Specialist	Va. counties approved for emergency conservation assistance as a result of damages caused by tropical storm Agnes

FIGURE 1



AGNES
24 JUNE 1972
23 JUNE 1972
22 JUNE 1972
AGNES
BEDFORD
Farmville

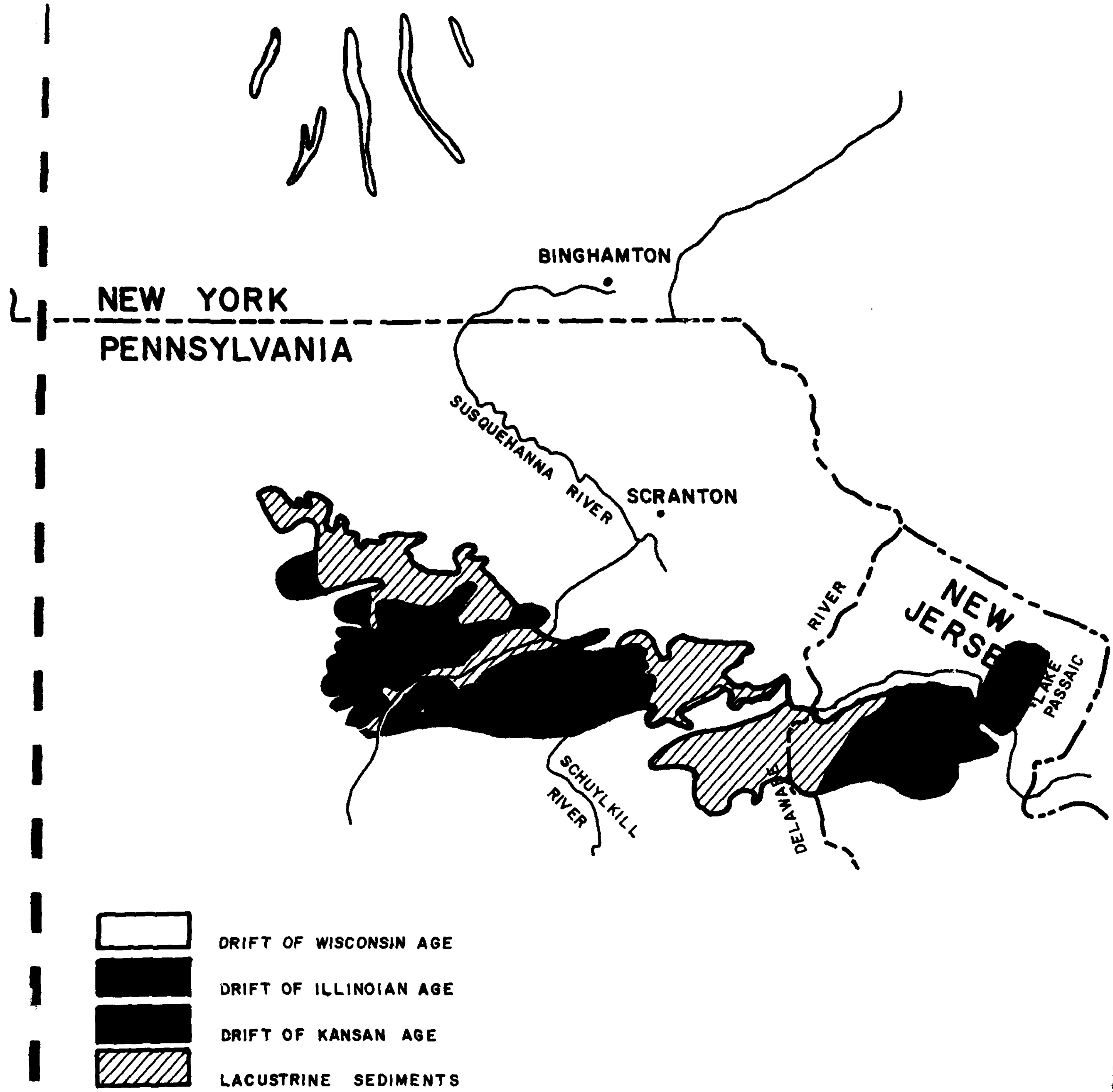
FIGURE 2



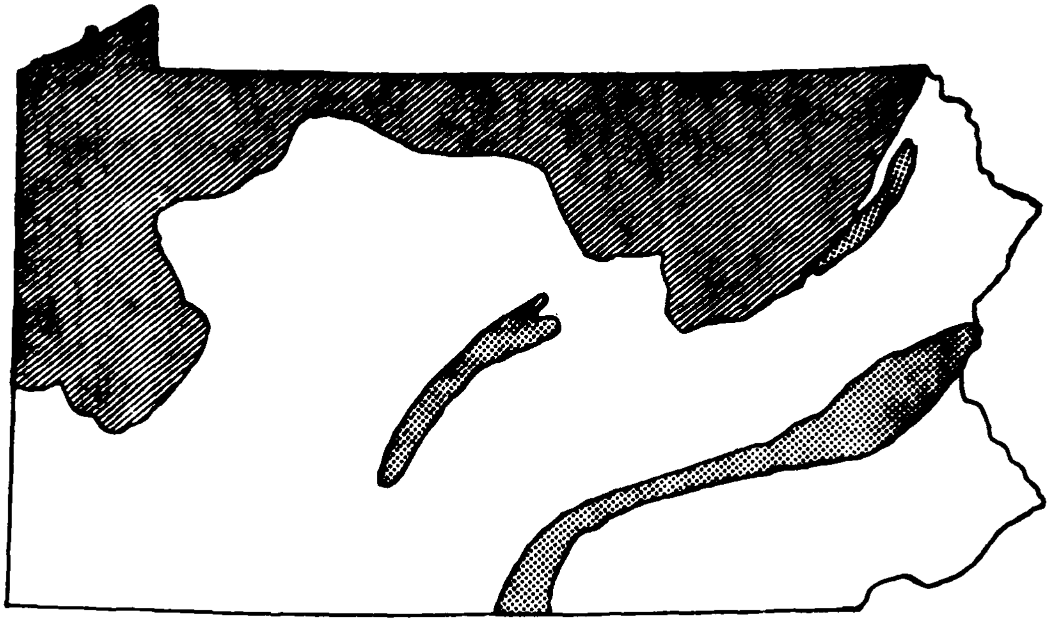
MAJOR RIVER BASINS

O'BRIEN & GERE ENGINEERS, INC.

FIGURE 3



GLACIAL DEPOSITS



5-300	5-1000	10-3000

YIELD IN GALLONS
PER MINUTE

NOTE

Large Yields Are From Glacial Outwash

O'BRIEN & GERE ENGINEERS, INC.
SYRACUSE, NEW YORK

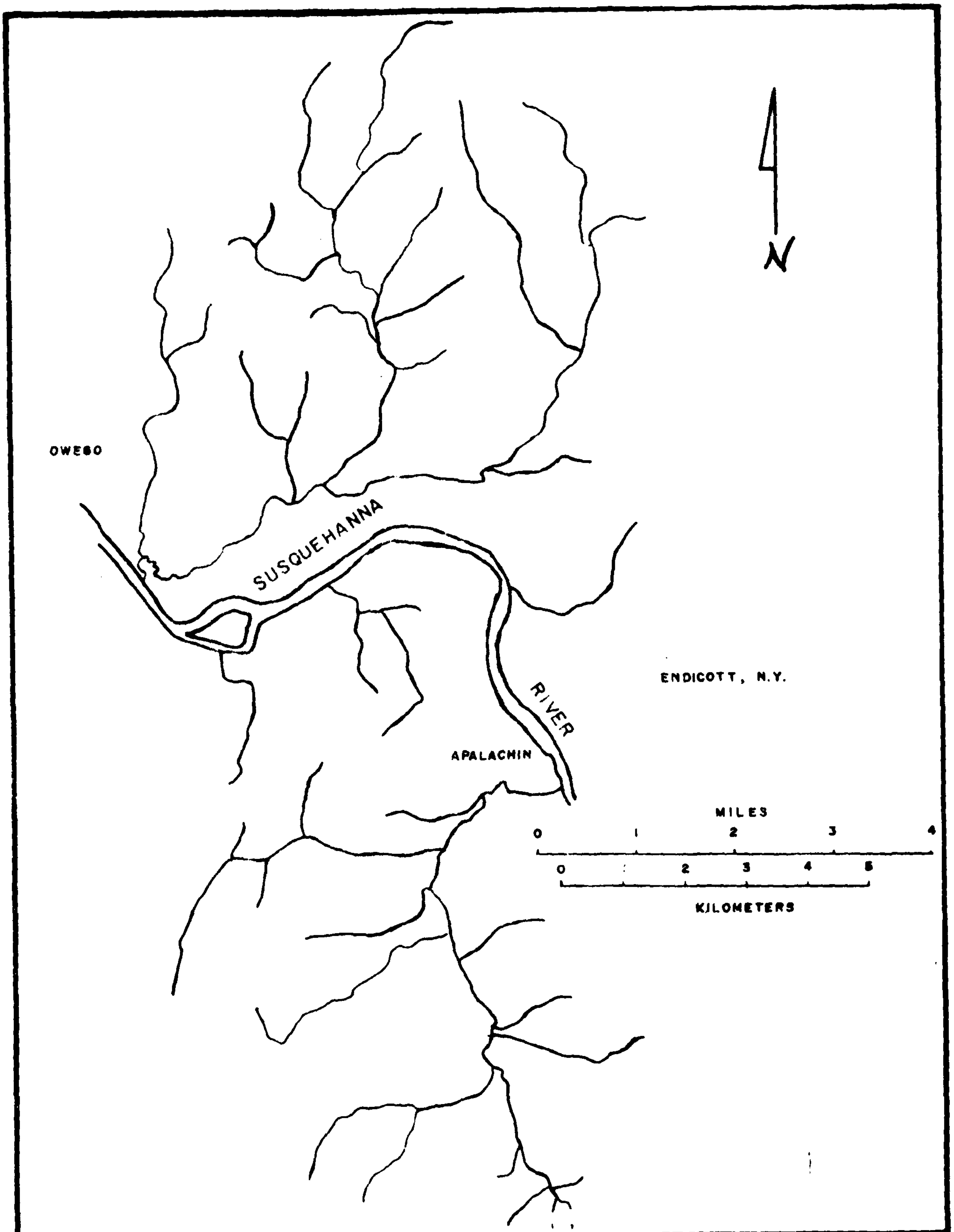
GROUND WATER LOCATIONS

PENNSYLVANIA

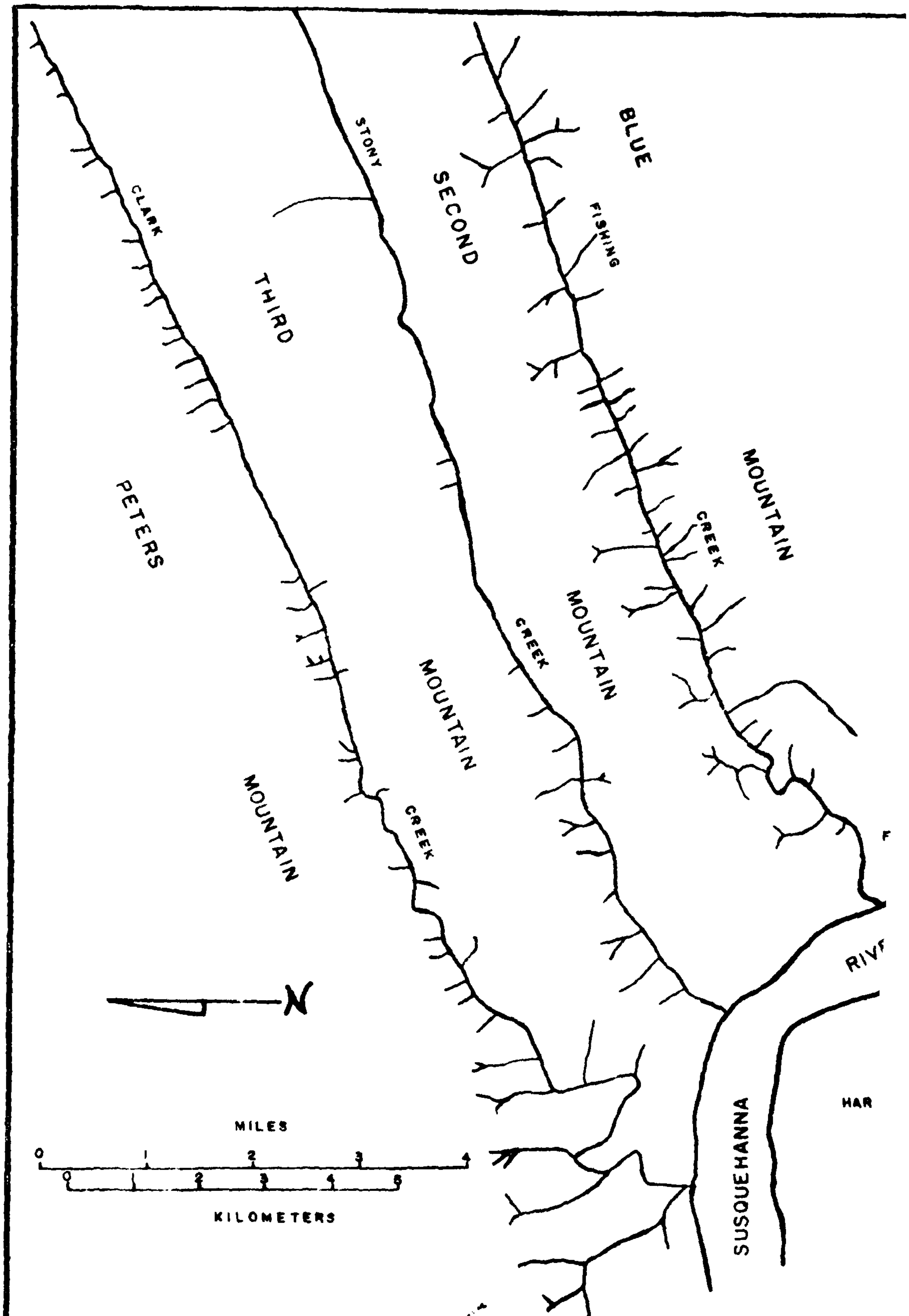
FILE NO. 333.008.

DATE

DWG NO. 4

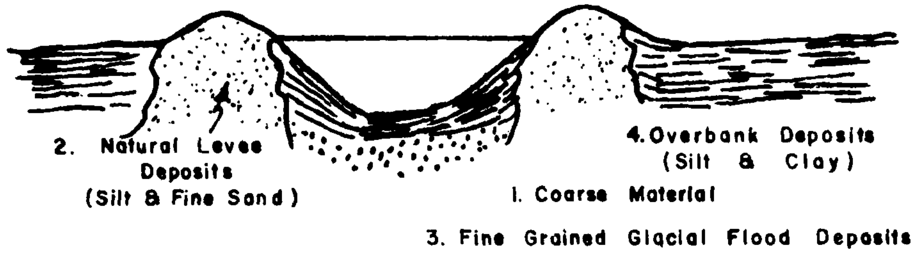


O'BRIEN & GERE ENGINEERS, INC SYRACUSE, NEW YORK	DRAINAGE PATTERNS SOUTHERN NEW YORK & NORTHERN PENNSYLVANIA	FILE NO 333.005. DATE DWG NO 5

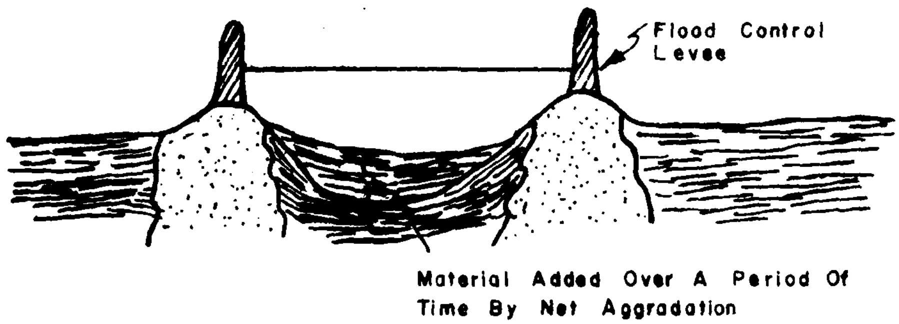


O'BRIEN & GERE ENGINEERS, INC.
SYRACUSE, NEW YORK

DRAINAGE PATTERNS
SOUTHERN PENNSYLVANIA



A.



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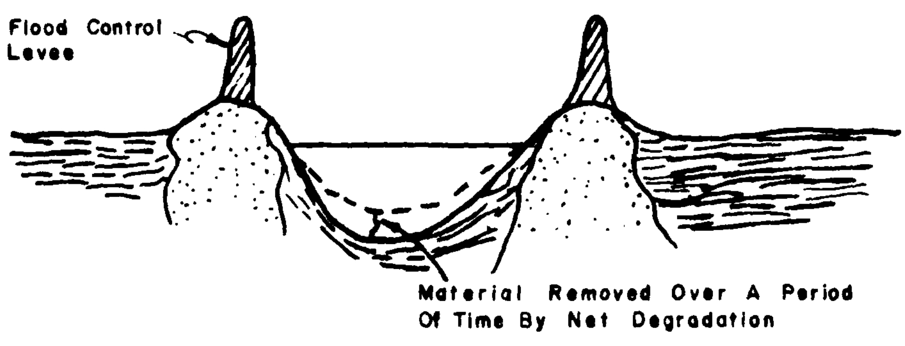
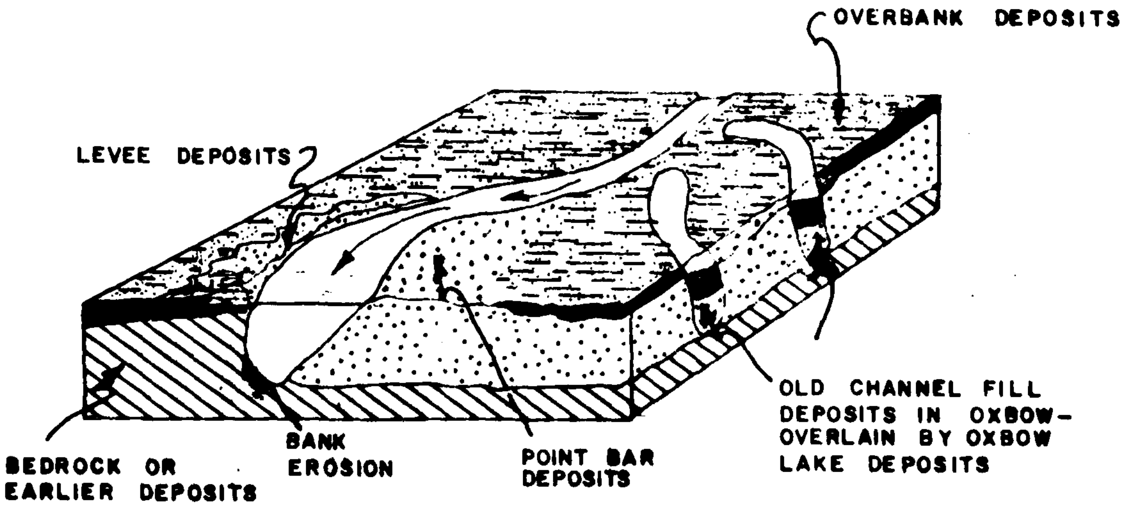


C.

O'BRIEN & GERE ENGINEERS, INC SYRACUSE, NEW YORK	AREAS OF SEDIMENTATION FOR NON MEANDERING STREAMS	FILE NO. 333.005. DATE DWG NO 7



O'BRIEN & GERE ENGINEERS, INC
SYRACUSE, NEW YORK

DEPOSITION PATTERN FOR A MEANDERING STREAM

FILE NO	333.006.
DATE	
DWG NO	8